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THE FOUNDRY TRADE JOURNAL IS THE OFFICIAL ORGAN OF THE INSTITUTE OF BRITISH FOUNDRYMEN; THE WELSH ENGINEERS' AND FOUNDERS' ASSOCIATION, AND THE FOUNDRY TRADES EQUIPMENT AND SUPPLIES ASSOCIATION.

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Secretary: F. J. Griffiths, 20, Fisher Street, Swansea.

Forthcoming Events.

OCTOBER 28.

Manchester Association of Engineers:—Ordinary meeting at Manchester. "The Design and Construction of Centrifugal Pumps," Paper by W. E. W. Millington.

OCTOBER 31-NOVEMBER 5.

Motor-Cycle and Cycle Exhibition, at the Olympia, London. W.

Institute of British Foundrymen.

OCTOBER 28.

London Junior Section:—Ordinary meeting. Chairman's address, followed by a lecture on "Science in the Foundry" by J. P. Ellis.

OCTOBER 29.

Institute of British Foundrymen:—Ordinary meeting at Newcastle-on-Tyne. "Steel Foundry Practice," Paper by A. D. Kirby.

NOVEMBER 3.

Birmingham, Coventry and West Midlands Branch:—Lecture on "Aluminium Bronze," by Dr. R. C. Reader.

London Branch:—Ordinary meeting in London. "Steel Making, with Special Reference to the Manufacture of Steel Castings," Paper by J. Deschamps.

NOVEMBER 5.

Lancashire Branch:—Joint meeting with the West Riding Branch at Huddersfield. "Metallurgy in Gear Manufacture," Paper by F. W. Rowe, M.I.M.M., F.C.S.

NOVEMBER 8.

Lancashire Branch (Burnley Section):—Ordinary meeting at Burnley. W. Holland will read a Paper on "Foundry Practice."

Colour.

Until casting time the old-fashioned grey iron-foundry was perhaps the dreariest place in the land, but with the arrival of the liquid metal, here and there colour sprang into being, and on account of this colour it assumed a different and more interesting aspect. It is always at casting time that visitors are introduced into the foundry—not because of the heat, the fume, and oftentimes the stench, but because of the impressiveness of the colour. Yet the majority of foundrymen have been slow to appreciate the real commercial value of colour when properly exploited. We have previously in this column told the pathetic story of British—good British—agricultural machinery being ignored at far-away exhibitions because it was painted a dreadnought grey, whilst foreign machines vied with one another to "out-rainbow" the rainbow. It is reasonably obvious that for the majority of the products of the foundry the colouring of castings would be a pure waste of time, but wherever the man in the street is the final purchaser, thought should be devoted to the potentialities of coloured articles.

Even where the nature of the article precludes permanent colouring, it is often worth while to stencil some distinctive mark upon the casting which vouches for the manufacturer's reputation. For some reason unremembered we are aware that a certain brand of foreign foundry shovel bears a red line. It may be no better nor worse than any of its competitors, but just because some imaginative person decided to give this product something of a "personality," it remains an article substantially the same as others, but christened and articulate. If ever this shovel ceases to maintain its hold on the market it will be for a reason other than that of its "red line."

We have noted with pleasure that the largest firm of weighing machinery manufacturers in Great Britain has provided scales other than the monotonous black variety, but the white or coloured typewriter is still a thing for future consideration.

Many machine shops are definitely clean, and there are scientific reasons why the stationary parts should not be painted grey or black. Black bodies absorb all light rays reaching them, and convert them into heat. We are aware that it would cost much money to paint and maintain white a large number of machine tools, but so does the provision and upkeep of a manicure department for the workers in certain food factories. Both have the common advantage of a good publicity, whilst the former also introduces the tangible asset of a decreased expense for lighting, with problematic benefits to be associated with the attraction of the best type of workers available in the district, who would be happier in the execution of their duties.

If ironfounders will but remind themselves of the commercial value of colour every time they notice the brightening up of the shop by the liquid metal, they will find a hundred-and-one little ways by which they can get into new markets or strengthen their ties with old ones by the reinforcement of their sales organisation by the judicious and daring utilisation of coloured castings.

The Ironfounder and the Nation's Savings.

During the past few years employers in the heavy industries have watched with considerable uneasiness and dissatisfaction the profits yielded by relatively non-essential or luxury trades as compared with the indifferent or negative returns that are all they have themselves achieved with great effort. Tobacco, brewing, confectionery, artificial silk, and similar trades, provide returns which make an ironfounder envious. The reasons are fairly clear: the luxury of pre-war years has become the necessity of to-day. Wages in the sheltered trades, backed in many cases by national or local taxes, or by statutorily fixed railway rates, have gone up to a higher level than the heavy industries, exposed as they are to foreign competition, can afford to pay. These increased wage-payments to those in stable occupations have on the whole been spent in maintaining a higher standard of living, which demands an increased consumption of such non-essentials as those mentioned above.

The founder sees clearly enough the disastrous results of this state of affairs. He can hardly be expected to find consolation in the suggestion that the interplay of economic forces will readjust matters in the course of the next generation. He is losing the stimulus that is so essential in the development of private enterprise under the crippling influence of national and municipal taxes. He sees the highly skilled men in the trade, greatly prized across the Atlantic and artists at their work, being tempted overseas or into other occupations, and he is powerless to interfere. In days when it is above all essential to spend money in order to be able to save it, he is utterly unable to accumulate capital.

Taxation discourages thrift on the part of the private individual no less than on that of the corporate body. Hence the general decline in savings—for savings are the margin beyond provision for current needs.

It may be argued that the non-essential industries use machines, and that foundries have a keen interest in the supply of such machines, to say nothing of a more direct interest in such articles as grand pianos, but this is a minor point. Before the war the people of the United Kingdom were adding to their overseas investments through savings at a rate of over two hundred millions per annum. During the past few

years the total has only been a third or a fourth of this, and during 1926, the year of the coal dispute, we actually borrowed from abroad instead of lending. When we invest overseas we are providing the capital which overseas industrialists will spend on heavy goods—"producers' goods"—made in England, and as our investments shrink so do the markets for our heavy goods.

Money that the ordinary citizen *spends* on "consumers' goods" goes to the machine-using industries, while the money he *saves* is indirectly spent on "producers' goods," that is, it goes to the machine-building industries. The founder's real market depends on what people save, not on what they spend, and much of our difficulty to-day is due to the alteration in the ratio between the two.

If the founder is to flourish, if conditions are to be stabilised, demand to increase, and prices to come down there must be more saving on the part of the average citizen, whether that saving replaces some part of his present outgoings in taxation or in spending.

Foundry's Heavy Loss.

Within a space of a few weeks, the Anderston Foundry, Port Clarence, Middlesbrough, has been deprived of three directors by death. First Mr. George Dawson passed away after a brief illness, his father, Mr. Edward Dawson, J.P., surviving him by less than a fortnight, and on Thursday of last week, exactly a week after he was first stricken with illness, Mr. Alexander T. Harvey, managing director of the firm, succumbed in a local nursing home. In industrial circles in Cleveland there were few men so well known and so widely respected as Mr. Harvey, to whose conspicuous abilities as a technician and a commercial organiser the success of the Anderston foundry was largely due. He was a Glasgow man, and served his apprenticeship at the Clydeside establishment of the firm. He first went to Tees-side in 1884, and by dint of unremitting industry and unswerving loyalty he rose to the position of managing director of the firm. He was 68 years of age, and the esteem in which he was held was reflected by the large and representative gathering which assembled at the funeral, which took place at Middlesbrough on Saturday last. Virtually the whole of the local employees of the firm, numbering 470, attended the service at St. Barnabas Church. In addition to the family mourners there were also present Mr. T. P. Cargill Glasgow, director; Mr. W. Morris, director; Mr. Wm. Hardie, Glasgow, secretary; Mr. F. A. Tubby, London representative; Mr. G. O. Cunningham, Mr. N. C. Close and Mr. F. H. Adcock, all representing the Anderston Foundry Company; Mr. Arthur Dorman, Mr. Russell, Mr. J. Hanson and Mr. Spencer, representing Dorman, Long & Company, Limited; Mr. George Hedley, Linthorpe Dinsdale Iron Company; Mr. G. B. Wencarrow; Mr. J. H. H. Tomlinson (Bolckow, Vaughan & Company, Limited), Mr. Felix Corbett, Mr. Harkess, Mr. H. A. Wood, Sir Wm Fawcett, Messrs. G. B. and R. W. Barnley, Mr. R. Wright, Mr. K. Ridley, Mr. W. Shaw, and Mr. A. Oswald (Blaydon).

Foundry Query.

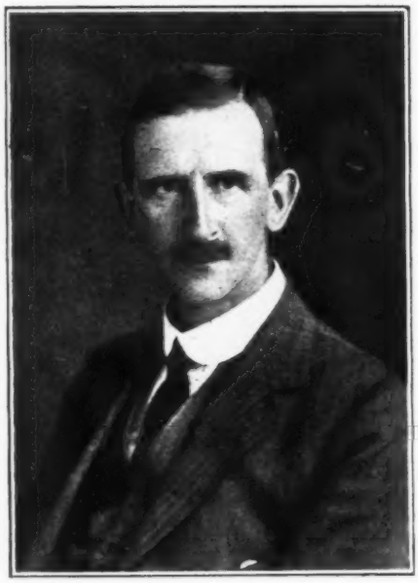
Casting Brass on Steel.

I have a problem to solve, and as I have had several attempts and not been too successful might I ask your advice? I have a pump ram to line with brass. The ram is approximately 5 ft. long and 2½ in. in dia. It has to be coated with brass to the extent of ⅛ in., except at one end, where for a length of about 6 in. the coating is ¾ in. thick. I have tried "casting on" one coat on the hot shaft, and then a second coat while still hot; but on account of the small amount of metal to be left on it has not eliminated the "pin holes" on top. Is there anything to coat the shaft with so that I can cast it on at once? However, I should like your observations on the matter.—J. B.

I.B.F. Branch Presidents.

No. 1.—Middlesbrough.

Mr. Frederick Portway Wilson, J.P., who has been re-elected president of this Branch, was born at Middlesbrough, 1869, and was educated at the Middlesbrough High School and Giggleswick Grammar School. He served his engineering apprenticeship as a premium pupil at the Tees-side Engine Works and R. Stephenson & Company, Limited, of Newcastle. He joined Wilsons, Pease & Company, Limited, Tees Iron Works, in 1892, eventually becoming assistant blast furnace manager, and associated especially with the development of slag wool manufacture direct from the blast furnace and from cupola-melted slag. Later became foundry manager to Pease and Partners, Limited, producing railway chairs and sleepers, brake blocks and other repetition work.



Mr. F. P. Wilson, J.P.,
President of the Middlesbrough Section of the I.B.F.

together with general jobbing work, ingot moulds, etc. He is the joint patentee in the expanded metal reinforcement for brake blocks, and carried out research work in special metal mixtures for brake blocks. Mr. Wilson is a member of Middlesbrough Education Committee, the Iron and Steel Institute, the Councils of Cleveland Institution of Engineers (and Past-President), the Constantine Technical College, the Cleveland Scientific and Technical Institute, and the Middlesbrough Chamber of Commerce, etc. Additionally, he is a member of the Magistrates' Licensing and Probation Committees and the Juvenile Organisations Committee. In addition to these activities Mr. Wilson has also filled the offices of Life Governor of the North Riding Infirmary; ex-President Y.M.C.A.; Assistant Commissioner of St. John Ambulance Brigade; Assistant County Controller of the North Riding V.A.D. and Serving Brother Order of the Hospital of St. John of Jerusalem.

New Companies.

Stedman Crowther & Company, Limited.—Capital, £20,000 in £1 shares. To acquire business carried on at 148½, Fenchurch Street, E.C., as Stedman Crowther & Company, Limited, metal merchants, etc. Directors: G. A. Lingner, A. J. Pryor, Lt.-Col. A. F. H. Simpson and Major W. H. Ward.

Sun Foundry Company, Limited, 326, Newtown Row, Birmingham.—Capital, £1,000 in £1 shares.

Whitewall Engineering Company, Limited.—Capital, £40,000 in £1 shares (20,000 10 per cent. cum. pref. and 20,000 ord.). Agreement with A. T. Frampton and A. W. Hussey-Vivian.

Random Shots.

Once upon a time the cry used to be "Every Man his Own Master." Now we are told on the best authority that it is "Every Man his Own Car." The second demand certainly seems to contradict the first—for no man who owns a car is his own master any longer . . . if he deny this, ask his wife! The car is maybe a kindly master, and one that, duly humoured and obeyed, is as useful as the best of servants—but still, a master. If not, why would any man spend half-an-hour on an open country road changing a wheel in a bitter east wind? Or waste the best part of a sunny Sunday morning performing a toilet no less elaborate than the grooming of a horse? Would any person of spirit be dictated to as to the number and weight of his passengers, the quantity of his luggage, the speed at which he may travel, the amount of juice he consumes, and so forth—unless the car were indeed his master? A useful master, one not sparing with his favours, if a little erratic, but—deny it if you can, all ye car-owners, and especially those newly-fledged among you who fell to the potent charms of this year's motor-show—indubitably a master . . . .

* * *

Anyone who has had occasion to visit the famous Cockerill works at Seraing, near Liége, in Belgium, will have been struck by the picturesque nature of the office buildings and their approaches. They have attracted a good deal of attention in connection with the recent celebration of their 110th anniversary, which was attended by the King of the Belgians, and it appears—and this will probably be news to many—that the original building was the château of the prince-Bishops of Liége, which accounts for its striking appearance and the formal gardens which are not usually an attribute even of the most progressive of works. . . . Locally, it is said, one still talks of being employed "at the château."

* * *

Great interest attaches to the appointment of Sir William Larke early this month to the Advisory Council to the Committee of the Privy Council for Scientific and Industrial Research. This body, which represents the Government in all matters pertaining to research, including the increasingly important Research Associations and such institutions as the National Physical Laboratory, has hitherto been felt to be almost in the nature of a preserve of the Fellows of the Royal Society, and other scientists with a bias towards the academic outlook. This latest appointment, therefore, is very welcome to industrial men as a sign of a distinct broadening tendency on the part of the body in question. That so distinguished a representative of the iron and steel interests of the country should be selected is by way of being a further compliment—that will be appreciated throughout the industry.

* * *

The motor ship continues to flourish and to increase in numbers and importance. Not long ago the Southern Railway announced that one of the new vessels it was having built for its various cross-Channel services would be of this nature, while we now hear that four new 16-knot motor vessels are to be laid down on the Clyde, and a further order has been placed for a twin-screw motor passenger liner of about 9,130 gross tons.

* * *

The School Inspector, after a strenuous morning, was lunching with the Squire, and in answer to the usual inquiries he was lamenting that on the whole the educational standard of the village left much to be desired.

"Just imagine," he said, "I asked 'em who signed Magna Carta, and it looked at first as if there wasn't one who could tell me. . . ."

"Disgraceful!" interjected the Squire.

"And then," the Inspector went on, "one little red-headed beggar—Freddy Jones, the name was, I think—puts up his hand and says: 'Please, Mister, it wasn't me!'"

"That little wretch?" said the Squire. "I'd believe anything of him. I wouldn't be a bit surprised if it came out that he'd done it after all!"

Marksman.

The Works of William Beardmore & Company, Limited, Mossend Steel Works.

These Works are situated at Mossend, on the main line of the London, Midland and Scottish Railway from Buchanan Street, Glasgow. The old part of the Works was acquired by Messrs. Beardmore in 1905, and was by them adapted for the manufacture of ship-plates and bars. During the war period, to enable them to help to meet the urgent demand for steel suitable for conversion into high-explosive shells, they erected a large new melting shop and converted their three-high plate mill into a billet mill suitable for rolling shell-bars. After the war the mill was restored to its original use, and to utilise the output from the new melting shop an up-to-date section mill has been installed with the necessary auxiliary plant for the manufacture of all standard sections for ship- and bridge-building purposes, and also rails.

Melting Shop.—The melting shop is housed in a building 1,200 ft. long, divided into three bays, each of approximately 67 ft. span. One of these is used as the marshalling and stock bay for the raw materials used in the shop; one contains the melting furnaces, 15 in number, whilst the third is the casting bay. The melting furnaces are of the usual gas-fired regenerative type, four being acid- and the remainder basic-lined, having a nominal capacity of 60 tons. They are served by four 5-ton Wellman open-hearth charging machines of the overhead revolving type, which lift the charging boxes from trestles in the marshalling bay and empty them into the furnaces. The steel is tapped from the furnaces into ladles, which are handled by five 100-ton overhead ladle cranes. The ingots for the section mill are cast on cars and transferred to the mills by a locomotive. The marshalling bay is served by six 5-ton overhead magnet cranes, which lift the scrap and pig-iron and load the charging boxes standing on the trestles already mentioned.

The gas for the melting shop is generated in 36 wet-bottom Morgan producers, fitted with the George mechanical feed. They are 10 ft. in diameter inside the brickwork and 12¼ ft. high, and are each capable of gasifying 10-12 cwts. of fuel per hour. They are housed in a building 672 ft. long, with a span of 14 ft. The fuel is received in four pits, into which the wagons are emptied mechanically, and from which the fuel is raised to the hoppers over the producers by three cranes provided with grab buckets. The ashes are also handled by grab buckets. The steam for blowing the producers is generated in four boilers adjacent to the bench.

Section Mills.—The standard ingots for the section mills weigh 3 tons, and after they have set sufficiently they are transferred on their cars to the stripping shed, where the moulds are removed by a hydraulic stripping crane and placed on empty cars standing on a parallel line of rails ready to be returned to the melting shop. The cars, with the stripped ingots on them, are then run forward to the ingot re-heating furnaces or soaking pits. The soaking pits are four in number and are of the Siemens gas-fired regenerative type. Each has seven cavities measuring 5½ ft. by 6½ ft. by 8 ft., each holding four 3-ton ingots. The soaking pits are housed in a building 360 ft. long by 83½ ft. span, with a lean-to building 200 ft. long by 33 ft. wide on each side. The covers for the soaking pits, one to each hole, are handled by electrically-operated lid-lifting cranes, two in number, running on rails outside of the furnaces. The gas for these soakers is generated in six Morgan producers, duplicates of those at the melting shop. When at the proper rolling temperature the ingots are withdrawn from the soakers and placed on the ingot carriage, which is electrically-operated, and which runs the ingot forward and automatically deposits it on the entering rack of the cogging mill.

Cogging Mill.—The cogging mill is of the two-high reversing type, having rolls 36 in. in diameter. It is provided with electrically-operated live-roller racks and screw-gear and hydraulically-operated manipulators. The mill is driven by a three-cylinder horizontal non-condensing reversing engine directly connected. The cylinders are 40 in. diameter and the stroke is 54 in. Each cylinder is provided with a piston valve operated by Joy's valve gear arranged to cut off at 70 per cent. of the stroke when in full gear. The engine operates with steam at a pressure of 160 lbs. per sq. in., superheated 100 deg. Fah. The maximum speed of the engine is 120 r.p.m., and at this speed, and with a mean effective pressure of 100 lbs. per sq. in. in the cylinders, it is capable of developing 12,000 i.h.p. The engine is provided with a trip gear, which automatically closes the stop valve should the speed of the engine reach 130 r.p.m. After cogging, the blooms are conveyed on a roller rack to a steam-hydraulic shearing machine, capable of exerting a pressure of 1,000 tons and of cutting blooms measuring 20 in. by 14 in.

Roughing Mill.—This mill has two stands of 32-in. rolls. The stand nearest the engine is used when rolling billets; the outer stand contains the roughing rolls for special sections. The mill is provided with electrically-operated live-roller racks and hydraulically-operated manipulators. It is driven by a three-crank engine, a duplicate of that driving the cogging mill.

Finishing Mill.—This mill has one stand of 32-in. rolls and has live-roller racks and manipulators, as at the roughing mill. It is also driven by a three-crank engine, a duplicate of the other two. The finished bars are conveyed to the cooling bed by a live-roller rack. There are two 60-in. hot saws, the first placed at 250 ft. and the second at 400 ft. from the mill.

Cooling Bed.—This bed is 120 ft. long by 93 ft. between centres of racks, and has mechanically-operated skids. The rack which conveys the cooled bars extends the full length of the loading bays, which are 420 ft. long by 340 ft. wide, divided into seven bays, each provided with a 5-ton crane, which loads the finished material on to railway wagons standing on one of four parallel lines of

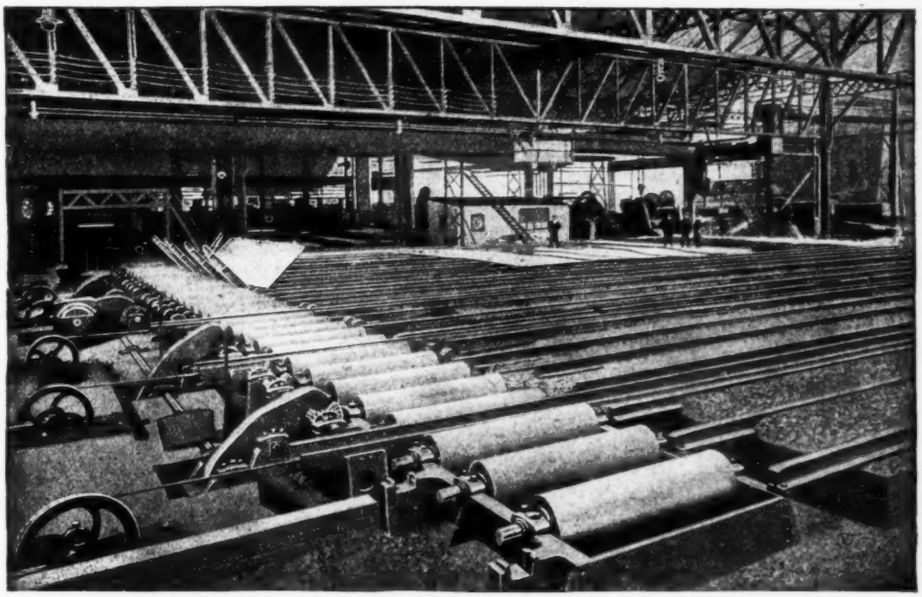


Fig. 1.—Mossend Works of Wm. Beardmore & Co., Ltd. Plate Mill, showing Mangle Rack, Turn-over Gear, and Marking-off Floor.

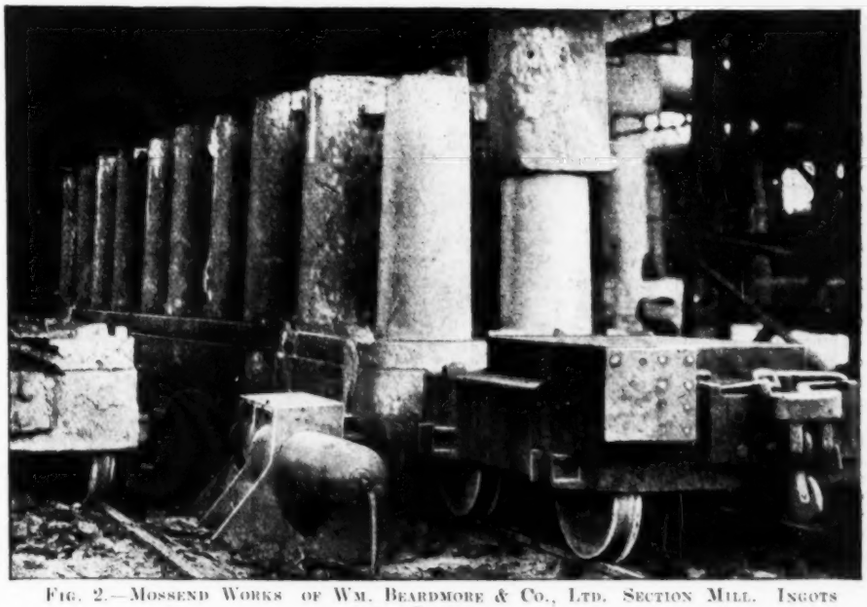


Fig. 2.—Mossend Works of Wm. Beardmore & Co., Ltd. Section Mill. Ingots being Stripped.

rails. The total length of the mill building from the end of the stripper bay to the end of the loading bays is 1,065 ft. For changing rolls and other purposes there is a 50-ton electric overhead crane over the cogging mill and its driving engine; also a crane of the same capacity over the roughing and finishing mills and their engines.

Rail-finishing Plant.—At the south side of the loading bays a rail-finishing plant is installed, consisting of straightening, ending and drilling machines.

Main Boiler Plant.—This is a thoroughly up-to-date plant, having six Babcock & Wilcox water-tube boilers, each with a heating surface of 6,196 sq. ft. They are each provided with integral superheaters and mechanical stokers of the under-feed type. Behind each boiler is an economiser with 1,910 sq. ft. of heating surface. The working pressure is 160 lbs. per sq. in., and the superheat is 100 deg. Fah. The boilers are operated on the balanced-draft system, air being blown under the grates by one of two pressure fans—one a stand-by—and the products of combustion are removed by induced-draft fans, one to each boiler. The boilers are fed by three Weir's direct-acting feed pumps.

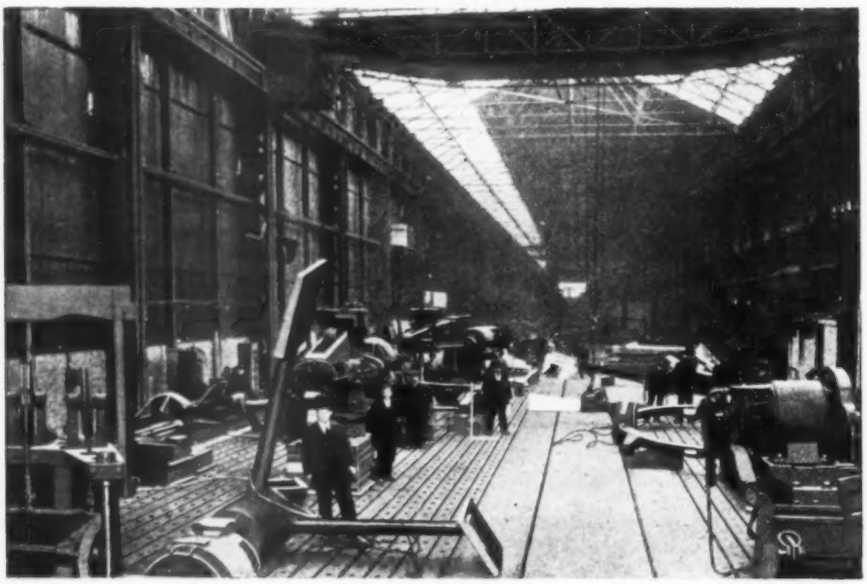


Fig. 3.—Mossend Works of Wm. Beardmore & Co., Ltd. Foundry Machine Shop, showing Cast-iron Floor and Dressing and Annealing Shops beyond.

The fuel is mechanically-handled by a gravity bucket conveyor.

No. 3 Power Station.—The exhaust steam from the three rolling-mill engines is taken to three thermal storage tanks or heat accumulators, each 42 ft. long by 8½ ft. in diameter, from which the steam is led to two mixed-pressure turbines geared to 1,000-k.w. direct-current generators, which supply current at 250 volts to the several cranes and auxiliary plant. It is inter-connected with No. 4 power station in the old works and to a converter station, which enables current to be taken, when required, from the Clyde Valley Electrical Power Company, Limited. In connection with this power station there are two natural-draft chimney-type cooling towers, each 92½ ft. long by 27 ft. broad.

Plate-Mill Department.—This is located in the old portion of the works, and comprises a slab-cogging mill, with slab shears and a three-high mill with the necessary shearing plant. The ingots are cast in No. 2 melting shop, and conveyed to the soaking pits by a locomotive. The soaking pits are three in number, of the usual gas-fired regenerative type, and are served by an overhead crane.

Slab-Cogging Mill.—This mill is of the standard two-high type, having rolls 40 in. diameter. It is provided with steam-driven live-roller racks. The mill is driven by a pair of horizontal non-condensing reversing engines, having steam cylinders 45 in. diameter, the stroke being 60 in. It is geared to the mill with double-helical spur wheels. The ingots, having been reduced to slabs in the mill, are transferred on live rollers to the slab shears, which are driven by a vertical steam engine, and are there cut to suitable slabs for the orders on hand. The slabs are then charged into the re-heating furnaces, four in number, which are of the Siemens regenerative type. The gas for these furnaces and for the soaking pits is generated in Mond-type producers and treated for the removal of the tar and ammonia.

Plate Mill.—This mill is of the Lauth three-high type, having two driven rolls each 29 in. diameter, and a centre roll, which is not driven, 21 in. diameter, the length of all being 92½ in. The mill is provided with lifting tables, front and back, hydraulically-balanced and electrically-operated. The mill is driven, through gearing, by a 1,500-h.h.p. direct-current motor running at 270 to 300 r.p.m. On the shaft, which is connected to the central pinion in the pinion housing, is mounted a flywheel 26.6 ft. diameter, which, when running at its normal speed of 70 to 75 r.p.m., has a storage energy of 33,600 h.p.-seconds. After being rolled, the plates are conveyed to a hot mangle, through which all plates are passed on their way to the cooling floor. The plates are skidded on rails over the cooling floor, and received on a rack, which conveys them to the shearing plant. Tumbling gear is provided on the cooling floor to enable plates to be turned over for inspection.

Shearing Plant.—There is one set of guillotine shears which removes the end scrap and cuts up such plates as have been rolled in multiple lengths. Side trimming, splitters and sketch plates are dealt with in other two shearing machines provided with casters. After shearing, the plates are conveyed on a live-roller rack over a weighing machine, and are then taken to the loading bay, where they are handled by overhead magnet cranes.

Light-Section Mill.—This is an electrically-operated three-high mill, having two stands of 16-in. rolls and a single stand for guides. It runs at 80 r.p.m., and has mounted on its driving shaft a flywheel 16 ft. diameter, which has a stored energy of 4,900 h.p.-seconds. The mill is driven through cotton ropes by a direct-current motor of 500 b.h.p. The billets for this mill are heated in an oil-fired continuous furnace.

Boiler Plant.—Steam is generated for the engines in the old works in a battery of ten Babcock & Wilcox boilers. The exhaust steam from all the engines is led to a heat accumulator which supplies No. 4 power station.

No. 4 Power Station.—This station contains a 1,000-k.w. direct-current generator geared to a mixed-pressure turbine. In connection with this station there is also a cooling tower of the same type as that at No. 3 station.

Repair Shops, etc.—For the repair and renewal of the plant there are provided spacious and well-equipped shops for mechanical and electrical engineers, roll turners, boilermakers and blacksmiths. There is the usual test house with two Buckton tensile-testing machines, also a well-equipped chemical laboratory.

Seaport Transport of Liquid Metal.

The Imperial Steelworks of Yawata are the largest in Japan, and turn out 60 per cent. of the total production of that country. They were erected some thirty years ago on European lines, and have since been considerably transformed and enlarged. Actually they comprise two 10-ton converters, and 26 Siemens furnaces of from 25 to 60 tons capacity, all being in actual operation. Additionally there are a 150-ton and a 200-ton mixer, whilst a 200-ton Talbot furnace is at present under construction. There are also two 3-ton electric furnaces, and a number of crucibles capable of making 7 tons per day. The actual production of ingots is 850,000 tons, whilst finished products amount to 650,000 tons.

The production of the six blast furnaces at Yawata is 500,000 tons of cast iron, but this is

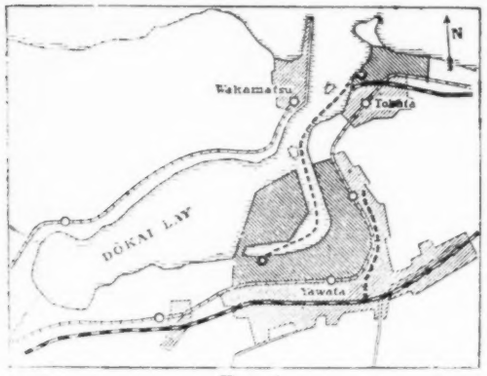


Fig. 1.

not sufficient for the steelworks, which require another 150,000 tons, which are made at the two blast furnaces at Tabato, which belong to the Imperial Steelworks. Furthermore, 130,000 tons of iron is imported from China. Thus there are 780,000 tons of iron melted annually in the steelworks, with an addition of 25 per cent. of scrap. Originally the transport of the liquid iron from Tabato was envisaged by railway, but local circumstances prevented the consummation of this project and recourse was made to sea transport between the two works, of which the respective geographical positions is shown in Fig. 1. The sea traffic is very considerable at the inlet from Dakai Bay, of which the width is only 535 metres.

Tabata and Wakamatsu are actually the principal ports for the export for the coal district of Chikuho, from where there is a monthly business of 650,000 tons. In spite of these difficulties the sea transport of liquid iron which started in September, 1925, has continued without any accident up to the present time. Three journeys are made daily. The metal is carried in two 20-ton ladles, which are lifted from the ship by means of 50-ton cranes. The ships make the journey at a rate of 3 to 4 knots per hour. On its arrival at Yawata the iron is teemed directly into the Siemens furnaces.

New Harriman Agreement.—A new agreement of the Harriman group with the Soviet Government is to come into force on January 1, 1928. The agreement of the German firm Rawack & Grunfeld with the Yurt (the South Russian Mining Trust) for working the manganese mines at Nikopol expires on the same date.

Developments in the Steel Castings Industry.

Mr. R. D. Moore, B.Sc., President of the Institution of Engineers and Shipbuilders in Scotland, as a portion of his Presidential address, dealt with the subject of steel castings, in the course of which he said that in 1883 a committee was appointed by the Admiralty to consider the use of steel castings in lieu of iron forgings, and as a result of their findings, larger steel castings came into use in British naval construction. The first British warships to be fitted with such castings were:—

Ship.	Commenced building.	Completed.	Casting.
"Forth" ..	Dec., 1884	July, 1889	Stern and sternpost.
"Fearless"	Sept., 1884	July, 1887	Stern and sternpost.
"Surprise"	Feb., 1884	Aug., 1886	Sternpost and shaft brackets.
"Alacrity"	Feb., 1884	Aug., 1886	Sternpost and shaft brackets.
"Benbow"	Nov., 1882	June, 1888	Shaft brackets.
"Thames"	April, 1884	July, 1888	Shaft brackets.

The use has steadily developed until, in a modern large cruiser, the total weight of steel castings amounts to over 700 tons, distributed between hull and machinery as stated below:—

Hull.	Tons.	Engines.	Tons.
Propeller brackets (4)	160	Thrust blocks ..	40
Stern	60	Valves and branches	140
Rudder frame ..	50	Other castings ..	70
Shaft tubes ..	70		
Hawse pipes, bollards, fairleads, etc. ..	110		
	450		250

Dr. Montgomerie informed the speaker that the date when a specification for steel castings first appeared under Lloyd's rules was 1889-90, in the section appertaining to keel, stem and stern posts. Fig. 1 shows the total yearly output of steel castings in the United Kingdom and Germany from 1913 to 1926. The large output by Germany during the war is very noticeable.

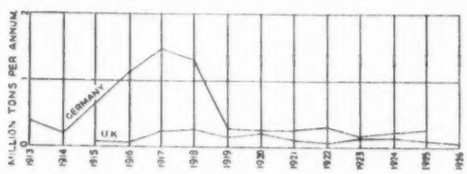


Fig. 1.

Steel suitable for rolled material, requiring only the addition of manganese (Mushet's discovery), gave porous metal when used for castings. This trouble, caused by occluded gases and dissolved oxides, was overcome by the steel founder after much bitter experience, by the addition of silicon or aluminium along with the manganese. The explanation of the action of silicon and aluminium was for a long time accepted as the simple one of the reducing effect of these easily-oxidised materials upon the gases and dissolved oxides in the steel. But later, when the analysis of gases in the cold steel came to be made, this theory had to be modified. An experiment was made with two ingots of steel taken from the same heat. To one, while molten, a quantity of aluminium was added; the other had no such addition. The resulting ingots showed that the steel without aluminium was honeycombed with blowholes, the other with aluminium addition was solid. The cold steels were then analysed for oxygen, carbonic oxide, carbonic acid, hydrogen, and nitrogen gases. The solid metal, with the addition of aluminium, gave the total volume of the gases equal to 91.86 times the volume of steel; while in the steel with blowholes and no aluminium the total volume of the gases was equal to 12.09 times the volume of steel. These results go to show that the effect of silicon and aluminium in preventing blowholes is due to the presence of these ingredients increasing the solvency of the occluded gases as well as reducing dissolved oxides.

An Ingot Viewed as a Casting.

An ingot is really the simplest form of steel casting, and in cooling from the molten to the solid state passes through various stages. The molten metal, in cooling, first sets on the outsides, in a manner analogous to the freezing of water. Contraction of this set portion takes place, causing the outside to press inwards, and to relieve the strains so set up, the metal elongates. The cooling of the outside portion continues at a diminishing rate, until a point is reached when the inside layers of the set portion begin to cool quicker than the outside. The effect of this is to cause the inside wall of set metal to contract towards the outside, and draw away from the melted metal in the interior, thus forming a cavity. Into this cavity the melted metal of the interior sinks, and continues to do so as long as a drop of molten metal remains. The cavity is due to piping, and the metal surrounding it is quite solid. An ingot of mild steel, 36 in. long by 9 in. sq. at the top and 12 in. sq. at the bottom (which has 0.2 per cent. of carbon) began to set on the top and outsides in two minutes, and was solid throughout in five minutes. With a large ingot of, say, 30 tons, the fluid metal in the centre would not solidify for about eight hours, and the piping would not be so far down. On the other hand, a section of metal cast, say, 1 in. thick, would set practically during the process of casting, and there would be no piping. It will be understood that, in casting, a feeding head of sufficient size to contain all the piping has to be provided, and this must not be less than one-third of the casting, and not of less section than the part which it feeds. The removal of large feeding heads, especially on parts inaccessible to cold cutting saws, gave rise to some difficulty until oxyacetylene cutting plant was adopted. A propeller boss had two heads, each 3 ft. 9 in. long and 18 in. at the thickest part. The time taken to remove each of these was 20 minutes, with a consumption of 324 cub. ft. of oxygen, and the cost of this, with the small quantity of acetylene used, was 10s. An operation of this kind recently undertaken was the cutting of the breech of a 15-in. gun. The metal in this case was 24 in. thick, and the length 5 ft. It is stated that 27 in. thickness of steel has been successfully cut by the oxyacetylene process. In castings generally about ½ in. of excess metal has to be left, and an objection to the oxyacetylene process is that the part in contact with the flame is burnt and becomes hard. This calls for removal by the electro-welder.

The operation of oxyacetylene cutting, when a guiding machine is used, is performed with great exactness. A certain line can be followed with an accuracy of within ¼ in., and the profiling machines effect great saving. It is thought that it has even been possible to cut out teeth in wheel blanks. Coal gas, though slower in operation, is now being used in place of acetylene gas, and it should be possible largely to replace oxygen with high-pressure air.

How Contraction Operates.

The contraction of steel from the molten stage to cold metal is from 1-5th in. to a foot. From experiments made, the speaker found that practically half the total contraction takes place during the cooling of the metal from the hottest fluid condition till just at the point of setting, while it is still plastic; the rest of the shrinkage from this point until cold, takes place in solid metal. The heat-resisting composition used in the mould hardens almost like concrete after drying, and this makes the question of shrinkage a very difficult one for the steel founder. In a small stern tube, 11 ft. long by 11½ in. outside, and 9½ in. inside diameter, there was a difference in length between the cast and the finished lengths of nearly 3 in. The main thickness of the tube being 1 in., the metal set almost immediately. The tube was cast on end to permit of free shrinkage as far as possible, and the core made soft to yield to the contraction towards the centre. There are two belts of thicker metal on the casting, and the method of bracketing to prevent the quicker-contracting thin metal drawing apart from the still liquid, or plastic, metal is shown. These ribs, which are of a section to correspond to the thinner metal, set quickly, and prevent fracture of the parts they protect. It is to be observed, however, that, owing to the unequal times of contracting, the casting when cold is in a state of great tension, and the ribs must be kept on till after the casting has been annealed. It is of the utmost importance, in dealing with castings liable to fracture during the process of cooling, that the materials from which the steel employed is made be free from excessive impurity. Sulphur is especially hurtful, because its effect begins when the metal is hot and in a condition of little strength.

Steel Propeller Manufacture.

Thirty years ago steel propellers and propeller blades were much in demand, but a serious objection to their use was their short life, owing to pitting caused by cavitation. The advent of bronze propellers offered many advantages, and lessened the demand for steel blades, except in cases where special strength was required, such as working in ice. Three per cent. nickel steel forms an excellent material for this purpose, and has the added advantage of resisting pitting to a large extent. The ideal propeller would be one made in rustless steel, but as the advantage in price still remains with bronze, there is no demand for this material. Solid steel propellers are nearly always moulded by sweeping, and this calls for care. Only one head can be put on the casting, and this on the boss, so it requires to be both large and high. The danger points are at the junction of the boss and blades, and cracking there can only be prevented by bracketing. Sometimes the curve and throwback of the blades hold them tightly and prevent free shrinkage. This trouble increases greatly with large diameters, and it is fortunate for the founder that these are seldom required, the boss with separate blades being most generally called for.

Making Gear Wheels.

Geared wheels and wheel blanks offer some difficulties in casting. The first risk with such castings, especially when large in diameter, is distortion in cooling, which results in the wheel becoming oval. A special danger point in blanks is in the rim at the junction of the arm, the lighter section of these tearing away from the heavier still fluid metal of the rim. A method of counteracting this which is quite successful consists in placing cast-iron chills in the moulds opposite these places. The chills are of sufficient thickness to cause the metal in the part of the rim to cool uniformly with the arms. A large wheel or rim cast in halves introduces another difficulty. In cooling, the ends draw out, due to the strains along the greater outside diameter after the metal has set. In a 10-ft. diameter ring cast in halves, an increase of 2 in. in the diameter may be caused in this way. This may be overcome by moulding out of truth to this extent.

Castings in connection with Belleville boilers were about the first to tax the ingenuity of the steel founder, but by the time this type of boiler went out of favour such advances had been made that reliable castings were readily produced. Valves and pipe connections, required in large quantities by the British Admiralty, at first gave some trouble in producing sound castings, owing generally to faulty design, from the steel founder's point of view. The trouble with the first valves lay in uneven thicknesses of metal, but with this difficulty removed the making of sound valves came to be a matter of careful moulding and the employment of suitable metal.

Light Intricate Castings.

A difficulty arises in connection with intricate castings of light section, such as valves, in providing test pieces. All surveys call for test pieces to be cast as an integral part of the casting. This

can only be done by casting the bars at the side, with a connecting attachment, so that not only is the casting endangered, but the metal comes to the test piece through the casting, and so is chilled and runs sluggishly. Consequently, good results are not obtained in this way, and the test piece is not representative of the casting. Under these circumstances, probably a departure from the present method of testing light castings might be made in favour of separate furnace-charge test pieces. These could even be tested unannealed.

Comparative results of a 16 per cent. carbon steel show:—

	Maximum stress. Tons per sq. in.	Yield point. Tons per sq. in.	Elongation on 2 in. Per cent.	Reduction of area. Per cent.
As cast ..	29.18	17.66	23	29.5
Annealed..	29.17	18.44	31	46.1

If satisfactory results were obtained, the castings could then be annealed in an approved oven, using a recording pyrometer. The heat diagram would be submitted to the surveyor as a preliminary to making the final examination of the castings.

The pioneer steel founder had many years of bitter experience before he overcame the many initial difficulties which confronted him. At the outset no doubt many defective steel castings were produced, and as these defects were generally only discovered on machining, the prejudice against steel castings may be said to have had reasonable foundation. The steel founder, however, has managed to survive, and now turns out a product which is quite as reliably sound as iron castings, and almost as strong as steel forgings.

During the past five years the industry has suffered more severely perhaps than any other in the country. The Washington Convention reduced the Admiralty requirements to small dimensions, and the rates of exchange, the longer hours, and lower wages of European competitors enabled them to get a firm hold on British markets. In 1924 the large castings imported principally from Germany and Czecho-Slovakia, and light castings from Holland, amounted to 6,641 tons, and of this quantity

Belgium	supplied	3,414 tons
Germany	,,	1,645 ,,
France	,,	149 ,,
United States	,,	191 ,,
Netherlands	,,	207 ,,

Importation of Castings Injures Industry.

At the exhibition in Düsseldorf, German steel founders made many enticing offers to induce British engineers and shipbuilders to accept their products. But this competition died away, as not only was it recognised that British steel castings were better but deliveries by Continental makers within a reasonable time could not be guaranteed. At present however it must be admitted that the large well-established Continental firms turn out castings which are at least quite as good in quality of material and moulding as those of any British firm. Indeed, in some cases, they seem to find special favour in this country. The author had the assurance of a managing director of a large engineering concern at Newcastle that, even before the war, he would get his steel castings, without consideration of price, from no other firm than Krupp, of Essen.

Not a few of the Clyde firms have also yielded to the temptation of cheaper prices. The wisdom of this is open to question. It is essential for the success of the shipbuilding and engineering industries that subsidiary manufactures, of which steel founding is one, should be in the position to continue to supply their products, and it may eventually be found that the temporary advantage has been dearly bought.

Any Paper dealing at the present time with statistics of a basic industry such as steel would not be complete without some pronouncement on Britain's ability to counteract the fierce competition of Continental firms. In 1924 Germany, having stabilised her financial position, set herself the task of organising her internal and external trade. As regards steel, this was relegated to an association called the "Rohstahlgemeinshaft," the primary object of this organisation being to regulate production in relation to the existing demand, and to fix prices. To make this effective, it was necessary to embrace not only Germany, but all the steel-producing countries of Europe. After many conferences, an agreement was drawn up, and signed in September, 1926, by Germany, France, Belgium, and Luxemburg, the allocations of production being, in the first instance—

	Per cent.
Germany	40.45
France	31.89
Belgium	12.57
Luxemburg	8.55
Saar { Germany, two-thirds / France, one-third }	6.54
	100.00

Meeting Foreign Competition.

In December, 1926, further conventions brought Austria, Hungary, and Czecho-Slovakia into the agreement, the whole organisation being controlled by Germany. Britain, the only remaining great European steel-producing country, stood aside in an attitude of friendly neutrality, preferring to encourage and develop her external trade with her dominions and possessions, of which India was her best customer, taking, in 1925, 480,801 tons of steel. But the advantage to the Continental combine of the German organisation soon became apparent, especially in the case of exported material, to which special preferences were given. The general effect was that Britain found herself quite unable to submit economic prices to the world's markets in competition with Continental makers. A comparison is given of the position at the present time:—

	British.		Continental.
	Home price, delivered locally.	Export, f.o.b. Glasgow.	Export, f.o.b.
	£ s. d.	£ s. d.	£ s. d.
Steel Ship plates..	8 2 6	7 12 6	7 0 0
,, Sections ..	7 12 6	7 2 6	4 10 0
,, Bars.. ..	8 12 6	8 2 6	4 13 6
,, Billets ..	—	—	4 5 0
,, Sheet bars ..	—	—	4 7 6

The disparity between prices of section bars, billets, and sheet bars is overwhelming, and the outstanding feature is that, while in the last few years the large British companies working on steel alone have lost money, the German steel companies have declared huge profits. Undoubtedly the Continental combine is making a strong effort to capture British markets, and kill her steel industry as a whole. But can Britain afford to let this happen? It will be remembered what an important part steel production played in winning the war. Steel-makers have brought before the Government the perilous nature of the position, and the Board of Trade has been called in to consider and advise. Belgium's official explanation is that she is able to produce steel more cheaply than Britain because her plant is more modern, and her workmen get less wages (30 per cent.) and work longer hours. On the face of it, this is quite a sufficient explanation. British users of Continental steel should, however, not forget that, with the stoppage of British steel production and the elimination of competition, there is no guarantee that the Continental combine will continue its apparent benevolent policy in respect to Britain. It is said that British steel-makers have not brought their plant up to the same efficiency as their great rivals in the United States, Germany, France, and Belgium, and it is probably true that the difficulty in finding money for fresh capital outlay has retarded development of British steel works during the last five years. Suggested remedies are all on the basis of reorganisation—this to take the form of amalgamation in groups; closing down of inefficient works, leaving the best equipped to work at their full capacity. Some alleviation of burdens is also called for; local rates and taxes under existing valuation scales press especially hard, and call for remedy.

Railway Rates too High.

The capitalist has reason for hesitation in investing in "industrials," when ahead of the ordinary return for his money ranks this appalling incidence of rates and taxes, so Government stock offers a greater inducement for investment. In some cases dissatisfaction with the use to which the money collected from taxation is put, and the uncertainty of settled labour conditions, have been instrumental in sending capital abroad for investment. Transport charges are far too heavy, but as the railways do not pay, and further consideration of this point leads to politics, it only remains to state that in comparison with Continental transport charges Britain is enormously handicapped. British railway rates on coal average 3s. 8d. per ton, being 83 per cent. in excess of the 1913 figure of 2s. per ton, while German rates have only increased by 41 per cent. A comparison of the present transport charges on coal with those in force before the war shows that in South Wales the percentage increase is 87—from 1s. 8½d. to 3s. 2¼d. The percentage increase on the Forth is 75, and on the Clyde 71. Taking account of the tonnage shipped at the various ports, the average transport charge in 1913 was 1s. 11½d., and in 1927 3s. 5¼d. In contrast to this, it should be noted that the index number of wholesale prices is only about 40 per cent. above the pre-war level. Further, the railway rate for export coal from a Scottish colliery to Glasgow, a distance of 35 miles, is 3s. 7d. per ton, and to Bo'ness, a distance of 18 miles, 2s. 6d. per ton, while from a Polish colliery to Danzig, a distance of 375 miles, the rate is 4s. per ton.

The Steel Rebate.

On September 1 last, a British steel combine offered rebates off steel prices ranging from 5s. to 7s. 6d. per ton to users who undertook to employ only British steel. This is a distinct advantage to the consumer and it is to be hoped that the larger outputs which it is anticipated will result from this scheme will go some way in the direction of cheapening the cost of production. How Britain will fare in this industrial struggle of competing nations, it is difficult to forecast. No doubt Britain has many advantages. It is an island, no part of which is far from the coast, where there are good harbours. There are coal, iron ore, and limestone in close proximity to one another, so that the making of iron and steel should be cheap; and the works are close to the harbours, so the cost of carriage of both the raw and finished material should be light. In Germany and the United States the raw materials have to be assembled from great distances, and when manufactured they are far away from the harbours, from which they have to be shipped. No doubt the rate of carriage of the goods per ton per mile is much cheaper in America and on the Continent than in Britain, but when transport distances are taken into account, the total sum to be paid for carriage is less in Britain than it is abroad. Then, though we all revile our climate, it is doubtful if there is any other place where work can be carried on outside for more days in the year than in Great Britain. We have an industrious body of skilled workmen as good, if not better than any others in the world, and our leading works are well organised and up to date. The great trouble with industry in this country is the political interference, and misguided labour leaders who hamper the workmen. After all, there is no more common-sense man in the world than the British workman, and doubtlessly he will in time see that it is in his interest to do his best and help industry. Even politicians may yet recognise that, for the benefit of the country, it is better to leave industry alone to work out its own salvation. "With a better understanding between employers and employees," said the President, "I have no fear for the future of our heavy industries. It is only some 30 years since trade unionism began to give trouble in British industry, and, after all, 30 years is but a short time in the life of a nation. We have come through the greatest war in history, and last year we passed through the longest strike on record. After such occurrences there is bound to be great disorganisation, from which it takes time to recover; but of our ultimate success I have no doubt."

The Theory of the Blast-Furnace Process.*

By Professor Dr. Fritz Wüst (Düsseldorf).

In text books and proceedings the view is generally held that the reduction of the manganous oxide, silica and phosphoric acid does not take place until after complete fusion of the carburised iron, and that it then occurs in the neighbourhood of the tuyères, that is, in the bosh. According to most investigators, the reduction of these oxides is effected by elementary carbon—that is to say, by so-called direct reduction. In the case of manganous oxide alone, the view is held by Jüptner, Wedding and Simmersbach that reduction can be effected also by carbon monoxide or by so-called indirect reduction.

From the following arguments it will be seen that manganese, silicon and phosphorus cannot be taken up by the iron in any considerable quantity in the blast-furnace bosh.

The iron trickling down in front of the tuyères will become burned to a considerable extent, due to the oxygen, the water and the carbon dioxide present in this oxidising zone. About 15 per cent. of the oxygen of the blast combines with the iron as it trickles down, causing the formation of very large quantities of ferrous oxide, which are taken up by the slag covering the metal. The slag thenceforth exercises a refining effect on the metal bath, just as in the open-hearth, and since the iron oxide reduced in this way is continuously replaced by fresh formation, any reduction of manganous oxide, silica and phosphoric acid can only take place if the iron-oxide content of the slag reaches an inconsiderable amount dependent on the temperature. Such a condition being scarcely likely to occur, these other oxides associated with the pig-iron cannot on theoretical grounds be taken up in the bosh below the tuyère level.

The reduction of manganous oxide, silica and phosphoric acid must accordingly take place above the tuyère level in the furnace, and a well-grounded but hitherto unnoted proof of this conception is furnished by the charcoal blast-furnace. In the older furnaces of this type, with open front, the bosh temperature was not very high, so that the metal sank slowly through the viscous slag, and there always remained a portion suspended in the slag as it ran off. By breaking and washing off the slag, this iron, called "washed iron" (Wascheisen), was recovered, and was re-charged into the furnace.

In the year 1885 the author began his practice in blast-furnace work at the ironworks of Wasseralfingen, rendered famous by Faber du Faur. Here there was a charcoal furnace in operation alongside of a coke blast furnace. An examination of the washed iron showed that it was already a pig-iron precisely the same in character as the simultaneously produced pig-iron from the furnace, and this fact being in complete opposition to the prevailing view, the author's trustworthiness as an analytical chemist was for a long time thereafter in doubt.

In 1910 the author examined samples of washed iron and of simultaneously produced pig-iron from five charcoal blast furnaces. The results are given in Table I.

A comparison of the composition of the washed iron with that of the iron run off at about the same time, in any case during the same tapping, reveals the correctness of the theory postulated at the opening of the Paper, and indicates with satisfactory clearness that the reduction of manganous oxide, silica and phosphoric acid must take place above the tuyère level. In the great majority of the cases the washed iron shows a higher content of foreign constituents than the simultaneously produced pig-iron. In Fig. 1, where the points of the curves lie above the zero line, this indicates that the percentages of silicon, manganese, phosphorus and sulphur in the washed iron are higher than in the pig-iron concurrently produced. The points below the zero line show that the opposite is the case.

In Table II the mean values are given for all the eleven samples of washed iron and pig-iron, together with the absolute and percentage differences.

Table I.—*Analyses of Washed Iron and Pig-Iron from Five Charcoal Blast Furnaces.*

Blast furnace No.	Sample mark.	Silicon.			Manganese.			Phosphorus.			Sulphur.		
		Washed iron.	Pig-iron.	Difference.	Washed iron.	Pig-iron.	Difference.	Washed iron.	Pig-iron.	Difference.	Washed iron.	Pig-iron.	Difference.
		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
I.	J1	2.32	0.73	+1.59	1.88	1.75	+0.13	0.17	0.11	+0.06	0.046	0.010	+0.036
I.	J2	2.00	0.84	+1.16	2.05	1.88	+0.17	0.15	0.11	+0.04	0.030	0.011	+0.019
I.	J3	2.02	0.52	+1.50	1.78	1.35	+0.43	0.16	0.10	+0.06	0.030	0.010	+0.020
I.	J4	2.14	0.57	+1.57	2.02	1.39	+0.63	0.16	0.10	+0.06	0.032	0.008	+0.024
II.	R1	2.11	1.41	+0.70	0.75	0.82	−0.07	0.84	0.67	+0.17	0.076	0.042	+0.034
II.	R2	2.13	1.43	+0.70	0.74	0.80	−0.06	0.80	0.63	+0.17	0.076	0.042	+0.034
III.	A1	2.43	1.02	+1.41	0.45	0.29	+0.16	1.03	0.65	+0.38	0.096	0.026	+0.070
I.	J5	2.67	1.20	+1.47	2.00	1.68	+0.32	0.12	0.11	+0.01	0.025	0.012	+0.013
IV.	Z1	1.96	1.31	+0.65	0.64	0.77	−0.13	0.98	0.73	+0.25	0.073	0.031	+0.042
V.	B1	1.16	1.25	−0.09	8.16	5.82	+2.35	0.14	0.10	+0.04	0.075	0.041	+0.034
V.	B2	1.75	0.80	+0.95	7.90	5.18	+2.72	0.11	0.09	+0.02	0.089	0.052	+0.037

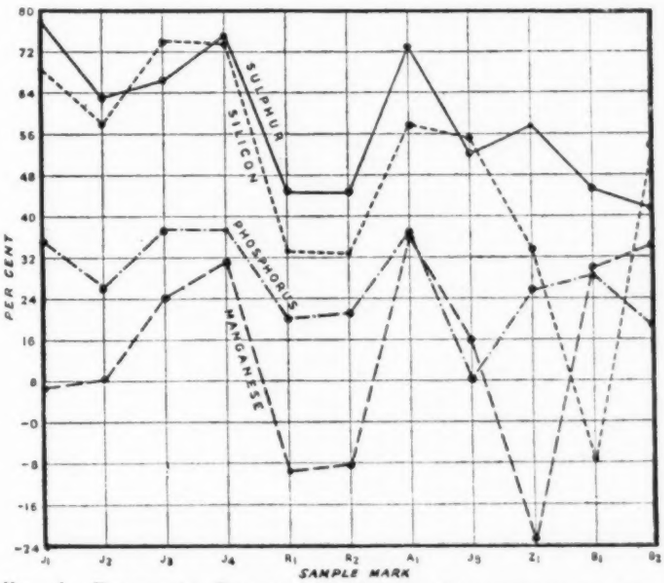


Fig. 1.—Percentage Decrease in Foreign Constituents in the Pig-iron as compared with Washed Iron from a Charcoal Blast Furnace.

With one exception in the case of silicon and three in the case of manganese (Fig. 1), the percentages of foreign constituents in the washed iron are all higher than in the concurrently produced iron. The explanation of this decrease as the iron enters the bosh is simple. The iron oxide formed in front of the tuyères is reduced by a portion of the foreign constituents of the pig-iron, causing these latter to become re-oxidised and taken up in the slag.

It is of course understood that the carbon of the pig-iron also bears its share in the reduction of the iron oxide of the slag. But with the low temperature of the charcoal blast furnace, the carbon gives way to the silicon, which accounts for the fact that out of the slag by the carbide carbon of the iron. This conception is, however, negatived by the fact that, so long as iron oxide is present in the slag in considerable quantity, a reduction of the above-mentioned oxides cannot take place. Therefore, the hitherto accepted theory, that the carbide

Table II.

	Washed iron.	Pig-iron.	Actual decrease.	Percentage difference.
	Per cent.	Per cent.	Per cent.	Per cent
Silicon ..	2.06	1.01	1.05	51.0
Manganese ..	2.58	1.975	0.605	23.4
Phosphorus ..	0.424	0.309	0.115	27.2
Sulphur ..	0.059	0.026	0.033	56.0

high-silicon pig-iron can be produced in the charcoal blast furnace only with difficulty. In the coke blast furnace the temperature of the bosh is much higher, and the slag in consequence is more fluid, so that under normal conditions no drops of iron remain suspended in it.

The author is, however, indebted to his friend, Dr. Neumark, at Lübeck, for the analyses of some samples of washed iron from a coke blast furnace, which, during a trial run, was worked with an exceptionally stiff slag. The composition of the washed iron and pig-iron samples is given in Table III. In Fig. 2 the percentage reductions of the constituents of the washed iron and those of the pig-iron are graphically represented in the same manner as in Fig. 1.

Table IV shows the difference in the mean composition of the sixteen samples of washed iron and pig-iron. It will be seen that although the differences in the mean composition of the washed iron and pig-iron are not of so high an order as in the case of the iron from the five charcoal blast furnaces, yet they are quite marked. This is due, first, to the lower concentration of the foreign constituents of the pig-iron, and, secondly, to the higher bosh temperature of the coke blast furnace, whereby the carbon has the leading share in the reduction of the iron oxide formed in front of the tuyères.

There might exist the possibility that during the retention of the washed iron in the slag, the silicon, manganese and phosphorus are reduced

* Read before the Autumn meeting of the Iron and Steel Institute.

carbon of the liquid pig-iron reduces manganous oxide, silica and phosphoric acid out of the slag, is untenable.

The carburised iron, which on account of its high carbide content has a high melting point, becomes fused at only quite a short distance above the tuyère level and then trickles down between the lumps of coke into the hearth. The time required to run through this space is too short to permit of any reaction on a considerable scale. Moreover, the slag trickling down at the same time as the iron is as a rule spatially separated from the iron, so that any reduction or taking up of foreign constituents during this period of the sinking down of the iron is quite out of the question. One is therefore forced to the conclusion that not only the carbon but all the foreign constituents of the iron are taken up as aggregates in solid form—in fact, by way of cementation—and that the pig-iron on becoming fused is already mainly in its final condition.

The carbon of the fuel probably plays only a very small part in the formation of the pig-iron, since the points of contact between ore and fuel are too few to produce any extensive effect.

Now, it has long been known, through the investigations of Sir Lowthian Bell, Ledebur, and others, that carbon monoxide in the presence of so-called contact materials, such as iron oxide, separates into elementary carbon and carbon dioxide, according to the equation,

$$2CO = C + CO_2.$$

Now in the temperature range from 850 to 350 deg. C. the carbon not only deposits on the surface of the ore, but, in the case of porous ores permeable to gas, it penetrates in such sufficient quantity as to make up in six to eight hours a considerable proportion of the weight of the ore. This finely-divided carbon is in close contact with the constituents of the ore. Due to its finely-divided state, it is extremely reactive, and thus promotes the work of reduction by the carbon monoxide until the last remnants of iron oxide are reduced. Part of this carbon sinks down with the reduced ore to the lower zones of the furnace, where with the iron it forms carbide and reduces at the corresponding temperature the manganous oxide, silica and phosphoric acid, and the elements on being set free are immediately taken up by the iron present. The dissociation of the carbon monoxide is a strongly exothermic reaction, and by the reaction $2CO = C + CO_2$ there are set free 38,960 kg.-cals. By coupling this dissociation process with that of direct reduction the following equation is obtained:—

$$\begin{array}{rl} & 2CO = C + CO_2 \\ FeO + & C = Fe + CO \\ \hline FeO + & CO = Fe + CO_2 \end{array}$$

From this it will be seen that thermo-technically the reaction proceeds according to the indirect reduction, which also is in agreement with the following equation for silicon, manganese and phosphorus:—

$$\begin{array}{rl} & 4CO = 2C + 2CO_2 \\ SiO_2 + & 2C = Si + 2CO \\ \hline SiO_2 + & 2CO = Si + 2CO_2 \quad . \quad . \quad . \quad \text{etc.} \end{array}$$

That is to say, these elements also are thermo-technically reduced only by carbon monoxide.

It is to be borne in mind, however, that the process of the dissociation of the carbon monoxide and of direct reduction go on in quite different zones of the blast furnace. Therefore the system as a whole is one of indirect reduction, while in the lower part of the furnace the consumption of heat is required for the direct reduction of manganous oxide, silica and phosphoric acid.

Thus the dissociation of the carbon monoxide, which is regarded by many blast-furnace men as an unfavourable condition, is, on the contrary, an essential requisite for economical working. Since the dissociation is considerable only at a temperature below 500 deg. C., a low top temperature is desirable in order to get the full advantage of it. The low temperature of the top gases obtained by heating the blast enables the separation of carbon in large quantities, and herein lies an hitherto unrecognised essentially favourable effect of the hot blast.

Simultaneously with the evolution of heat which accompanies the dissociation of the carbon monoxide, a remarkable delay in the fall of the temperature within the shaft takes place, which permits the indirect reduction to take its course more fully.

The investigations of Levin and Niedt show that in a blast furnace 18 m. (60 ft.) high the temperature between heights of 4.6 m. (15 ft.) up to 13.9 m. (45½ ft.) above the tuyère level falls from about 800 deg. to about 700 deg.—that is, the gases are able to effect indirect reduction throughout a height of 9 m., or, say, half the height of the furnace.

It then becomes explicable why those ores which are interspersed with fine quartz particles are so particularly suitable for the production of high-silicon pig-iron, this being the most favourable condition under which the finely-divided carbon can exercise its reducing effect. If, as has been hitherto assumed, a reduction of the silicon from the slag takes place, then the extent to which this happens would be entirely independent of the petrographic quality of the ore.

The foregoing theoretical considerations have been fully confirmed by practical tests. By the kindness of the Notgemeinschaft der Deutschen Wissenschaft, the author has been enabled to investigate this new theory by means of experiments, which were carried out by Dr. H. H. Meyer in the Iron Research Institute (Düsseldorf). The reducing agents employed were hydrogen, carbon monoxide and elementary carbon in a temperature range of 800 to 1,200 deg. C., and as basis were used silica, manganous oxide and phosphoric acid, the latter in the form of basic slag. After reduction, the quantity of phosphorus, silicon and manganese taken up by the iron was determined. A portion of the results of the investigation are summarised in Table V. In none

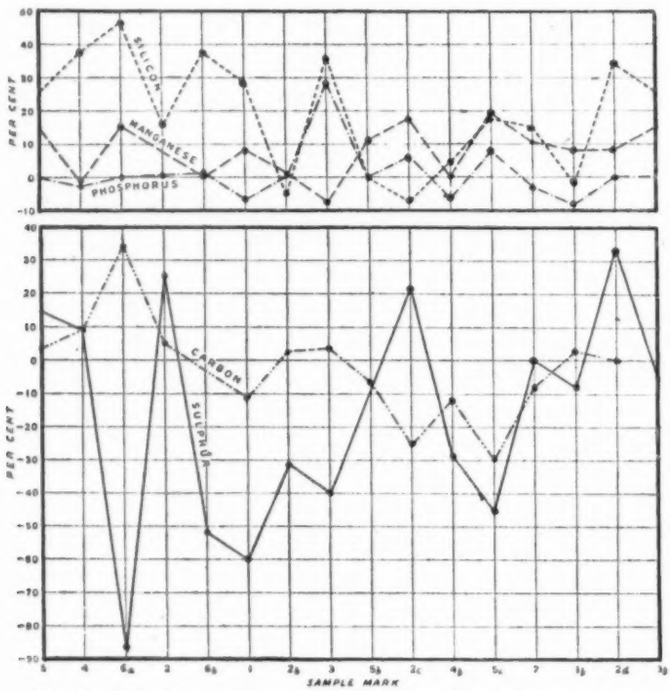


Fig. 2.—Percentage Decrease in Foreign Constituents in the Pig-iron as compared with Iron from a Coke Blast Furnace.

Table III.—*Comparison of Analyses of Washed Iron and Pig-Iron from a Coke Blast Furnace.*

Tapping No.	Silicon.			Manganese.			Phosphorus.			Sulphur.			Carbon.		
	Washed iron.	Pig-iron.	Difference.	Washed iron.	Pig-iron.	Difference.	Washed iron.	Pig-iron.	Difference.	Washed iron.	Pig-iron.	Difference.	Washed iron.	Pig-iron.	Difference.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
5	1.10	0.82	+0.28	0.81	0.69	+0.12	0.15	0.15	0.0	0.048	0.041	+0.007	4.49	4.33	+0.16
4	0.99	0.62	+0.37	0.69	0.70	−0.01	0.11	0.14	−0.03	0.022	0.020	+0.002	4.99	4.55	+0.44
6a	0.58	0.31	+0.27	0.66	0.56	+0.10	0.12	0.12	0.0	0.030	0.056	−0.026	6.37	4.21	+2.16
2	0.82	0.69	+0.13	0.64	—	—	0.15	—	—	0.043	0.032	+0.011	4.82	4.55	+0.27
6b	0.99	0.62	+0.37	0.71	0.71	0.0	0.16	0.14	+0.02	0.025	0.038	−0.013	4.43	4.57	−0.14
1	0.98	0.70	+0.28	0.75	0.69	+0.06	0.15	0.16	−0.01	0.025	0.040	−0.015	4.22	4.70	−0.48
2b	0.78	0.82	−0.04	0.65	0.64	+0.01	0.10	0.10	0.0	0.035	0.046	−0.011	4.66	4.54	+0.12
3	1.17	0.75	+0.42	0.67	0.72	−0.05	0.14	0.10	+0.04	0.035	0.049	−0.014	4.61	4.45	+0.16
5b	0.56	0.56	0.0	0.73	0.65	+0.08	0.15	0.15	0.0	0.060	0.065	−0.005	4.13	4.38	−0.25
2c	0.68	0.73	−0.05	0.68	0.56	+0.12	0.16	0.15	+0.01	0.032	0.025	+0.007	3.88	4.88	−1.00
4b	0.93	0.89	+0.04	0.60	0.60	0.0	0.16	0.17	−0.01	0.024	0.029	−0.005	4.01	4.49	−0.48
5c	0.80	0.66	+0.14	0.88	0.71	+0.17	0.114	0.105	+0.009	0.020	0.029	−0.009	3.53	4.58	−1.05
7	0.93	0.79	+0.14	0.76	0.68	+0.08	0.103	0.106	−0.003	0.020	0.020	0.0	4.19	4.54	−0.35
1b	1.39	1.42	−0.03	0.74	0.68	+0.06	0.12	0.13	−0.01	0.025	0.027	−0.002	4.65	4.53	+0.12
2d	1.67	1.10	+0.57	0.73	0.67	+0.06	0.14	0.14	0.0	0.030	0.020	+0.010	4.58	4.58	0.0
3b	1.01	0.75	+0.26	0.74	0.63	+0.11	0.14	0.14	0.0	0.041	0.043	−0.002	4.29	4.29	0.0

Table IV.

	Washed iron.	Pig-iron.	Actual difference.	Percentage difference.
	Per cent.	Per cent.	Per cent.	Per cent.
Silicon ..	0.945	0.747	+0.198	+ 20.8
Manganese ..	0.720	0.618	+0.102	+ 14.2
Phosphorus ..	0.134	0.133	+0.001	+ 0.75
Sulphur ..	0.0322	0.0360	−0.0038	− 11.8
Carbon ..	4.49	4.50	−0.01	− 0.22

of the tests were any fusion and scarcely any sintering observable. The last column of the table shows the kind of iron employed. The electrolytic iron was in the form of prismatic pieces; after the tests with manganese and phosphorus a 0.5-mm. thick layer, and after that with silicon a 1-mm. thick layer, was removed and analysed.

The tests with hydrogen showed that manganous oxide alone was reducible by hydrogen, while phosphoric acid and silica remained unaffected, as may be seen from the tests Nos. 2, 5 and 58 in Table V.

Table V.

Test No.	Reducing agent.	Temperature. Deg.C.	Time, hrs.	Analysis.	Kind of iron
2	H_2	1,100	7¾	8% Mn	Electrolytic
5	H_2	1,150	9	0.07% P	,,
58	H_2	1,200	5	0.03% Si	,,
51	CO	1,150	5	3.80% Mn	Floral wire
59	CO	1,200	5	0.27% P	,,
59	CO	1,200	5	0.04% Si	,,
32	C	1,100	4	5% Mn	,,
55	C	1,170	5	7.97% P	,,
57	C	1,170	5	2.55% Si	,,
21	C	1,100	4	1.45% Mn	Electrolytic
13	C	1,150	4	1.44% P	,,
56	C	1,170	5	1.32% Si	,,

In using carbon monoxide as reducing agent care must be taken to avoid the separation of carbon, which takes place below 1,000 deg. C. On this account the test-pieces were not placed in the furnace until the temperature for the experiment had been reached. As will be seen from Table V, manganous oxide is likewise reducible by carbon monoxide, and so apparently is phosphoric acid according to the analysis of test 59. The floral wire used contained originally 0.11 per cent. phosphorus, and therefore 0.16 per cent. phosphorus must have been taken up by reduction. A sample of the wire after annealing for five hours at 1,200 deg. C. in carbon monoxide was found to contain 0.32 per cent. carbon, the original carbon having been 0.04 per cent. At these temperatures the carbon monoxide reacts with the iron, forming carbide, and it is probable that this carbon exercises a reducing action on the phosphoric acid, while the silica is not affected.

The tests with solid carbon resulted in the reduction of all three oxides while in the solid state. The oxides were mixed with coal and showed no sign of sintering. On comparing tests 2 and 21 it will be noted that hydrogen has a stronger reducing effect than carbon on manganous oxide. The lower reducing effect of carbon is probably due to the formation of manganese carbide, which impedes the diffusion of the manganese into the iron.

The temperatures at which the reduction of the oxides by solid carbon in the presence of iron started were determined as follows: Manganous oxide at 900 deg., phosphoric acid at 1,050 deg., and silica at 1,100 deg. C. That is, the reduction of the oxides takes place at a temperature below the melting point of pig-iron, and not, as is generally assumed, after it reaches the liquid state.

All reactions in the solid state, such as have frequently formed the subject of investigation by Tammann and Hedvall, depend, of course, very largely on the intimate mixing, the contact, and the area of the surfaces. The influence of the surface is clearly evident in the reduction tests with solid carbon, as recorded in Table V. In those where floral wire was used—that is, where the surface was larger—the reduction is much stronger than with the electrolytic iron. The floral wire after four hours' annealing at 1,100 deg. contained 5 per cent. manganese, while the electrolytic iron showed only 1.45 per cent. manganese in the 0.5-mm. thick outer layer under the same conditions.

In the blast furnace the reduction of the iron oxides is about complete when the burden has reached a temperature of 800 deg. The next lower zone down to the melting zone is often regarded as a zone of chemical inactivity. The results of the reduction tests have shown that this view is not correct, but that shortly after the reduction of the iron oxide is ended and before the burden sinks down into the melting zone, the reduction of the manganous oxide and of the other oxides sets in.

The conditions for reduction in the blast furnace are far more favourable than in the tests as carried out. The iron is present in the blast furnace as iron sponge, and being intimately mixed with the oxides, it presents the largest possible superficial area to the accompanying elements diffusing into it.

Heat Treatment of Aluminium Alloys.*

By R. S. Archer.

To those not especially familiar with the subject, it may be surprising to learn the extent to which the properties of aluminium alloys may be altered by heat treatment.

It is common to regard the hardening of steel by heat treatment as a unique phenomenon. Pure iron has a Brinell hardness of approximately 75. By the addition of carbon with or without the common alloying elements, steel may be produced whose hardness can be raised to perhaps 750 by heat treatment. The combination of alloying and heat treatment has thus given a product with a hardness about ten times that of the pure iron.

Pure aluminium (99.95 per cent.) has a Brinell hardness of about 15. Light aluminium alloys can be produced which can be mechanically worked and which can be heat treated to a Brinell hardness of approximately 150. The increase is again about ten to one. Considering the possibilities of heat treatment alone, it may be mentioned that an alloy of the aluminium-magnesium-silicon type may be annealed to a Brinell hardness of about 28 and hardened to a Brinell hardness of about 120. This change compares closely with the increase in hardness of annealed tool steel by hardening.

The development of the common duralumin type of alloy (aluminium-copper-magnesium) some 15 years ago has been followed by the development of other types of high strength aluminium alloys of which the following may be mentioned:—

(1) Aluminium-copper-manganese-silicon (known as 25S); (2) aluminium-copper-silicon (Lautal); (3) aluminium-magnesium-silicon (51S); (4) aluminium-copper - magnesium - silicon-manganese (special 17S, or "superduralumin"); (5) aluminium-zinc-magnesium (Constructal); (6) aluminium-zinc-copper-magnesium ("E" alloy, National Physical Laboratory), and (7) aluminium-copper-nickel-magnesium ("Y" alloy, National Physical Laboratory).

These various alloys, and some others which have not been mentioned, show after heat-treatment physical properties covering a fairly wide range with tensile strengths from about 15 to 39 tons per sq. in. and elongations from about 10 to 30 per cent. The alloys which are at present most generally used for structural purposes develop a strength of about 26 tons per sq. in. with an elongation of about 18 per cent. Some of the heat-treated products may be further hardened by cold working, with reduced ductility, of course.

The various alloys, even when possessing approximately the same tensile properties, may show certain differences in other properties which are important from the standpoint of either use or fabrication. Many alloy steels are used which give approximately the same hardness and tensile properties, but which differ materially as to ease of rolling, forging, machining, or heat-treating.

The very recent and present tendency is in the development of fabricating processes rather than the development of more types of alloy. Much progress has been made in reducing to a production basis the manufacture of various wrought forms such as rod, tubing, sheet, forgings, and screw machine products. A rather striking achievement in the forging art is the production of the forged crank cases used on the new Pratt & Whitney aircraft engines. The development of the forged aluminium alloy aircraft propeller is also a notable accomplishment, both from the standpoint of fabrication and design. These propellers are rapidly becoming popular—it was with one of them that Lindbergh made his recent flight to Paris.

The materials just referred to are all wrought products. When it is desired to obtain maximum physical properties in castings, it is found that somewhat different alloy compositions and different heat-treating processes give better results than those used for the wrought alloys.

Within the last few years the heat treatment of aluminium alloy castings has grown from a laboratory basis to a commercial production of some magnitude. The problems of heat-treating and quenching complicated castings have been worked out, and it is now possible to heat-treat practically any type of casting.

The heat-treated castings do not develop as good physical properties as the heat-treated wrought alloys. Various combinations of strength and elongation are obtained from about 14 tons per sq. in. with 8 per cent. elongation to about 20 tons per sq. in. with 1 per cent. elongation. These are average values rather than specification figures. Castings may also be heat-treated to increase their hardness, as in the case of aluminium alloy pistons.

The marked modern tendency to save weight in all forms of transportation equipment points to a rapid increase in the use of the heat-treated aluminium products.

* From the "Iron Age." The Author is Research Metallurgist to the Aluminium Company of America, Cleveland.

Certain Psychological Aspects of Accident Causation.

Before Section J (Psychology) of the British Association at its recent meeting, Mr. Eric Farmer read a Paper on "Certain Psychological Aspects of Accident Causation," giving an account of some researches by the Industrial Fatigue Research Board, with the object of ascertaining if individual differences in accident liability manifested were in any way connected with other measurable personal differences. Various industrial groups were selected, mostly from the engineering trades, in which each individual's exposure to risk was as far as possible the same, and different tests were given them to compare their performance in the tests with the number of accidents sustained over a given period. The Board is continuing this inquiry with a view to determining the validity of the tests that have already given positive results, and also to examining other psychological qualities that may possibly be connected with accident liability, but some time must elapse before any further results founded on sufficient data are likely to be forthcoming.

One interesting result of the Board's psychological inquiry into the personal factor of accident causation is—it is claimed—that it gives an unmistakable indication that the difference in accident liability between individuals can no longer be attributed to a difference in exposure to risks, since those who have a high accident rate have been found to differ in other measurable qualities from those who have a low accident rate. As the tests were given in most cases before the accidents had been sustained by the individuals concerned it had to be assumed, in order to hold the view that difference in accident liability is solely a matter of difference in exposure, that those who failed at the tests tended, on the whole, to be exposed to greater risk than others, but such an assumption was very unlikely. This psychological inquiry has shown that the difference in accident liability is connected with other measurable personal differences and is therefore a real personal difference and cannot be accounted for merely by a difference in exposure to risk.

A positive correlation was found to exist between the frequencies of trivial and serious accidents, and also between the number of accidents and the number of sicknesses. There was also evidence to show that the industrially inefficient sustained more accidents than others. This latter point, however, needed further substantiation before it could be accepted with any confidence.

Institute of British Foundrymen.

West Yorkshire Branch Opens New Session.

The session of the West Riding of Yorkshire Branch of the Institute of British Foundrymen was opened on October 8, at the Bradford Technical College, when there was an excellent attendance of members from many parts of the branch area.

In the opening stages of the meeting the chair was occupied by Mr. W. G. Thornton, of Bradford (Vice-President), for the delivery of the Presidential Address by Mr. W. Parker (Sheffield), in the course of which he said:—

Mr. Thornton and Gentlemen,—In addressing you this evening I do so with a great deal of pleasure and with a certain feeling of diffidence. I can assure you of my appreciation of the honour you have done me in re-electing me to this office.

Evolution of the Modern Foundrymen.

Foundry work is always fascinating, even if it is accompanied by a certainty of worry. Undoubtedly the art or craft of a foundryman ranks very high, and it is the duty of all to see that the standard is maintained. Unfortunately, and for some inexplicable reason, the foundry industry until recently did not attain that status which was its right, and in thinking over this matter, one is rather driven to the conclusion that the neglect was probably due more to the foundryman himself than to any other cause, and probably one reason for this was the Bohemian character of the old craftsman.

Founding is more of an art than any other of the industrial operations, and whilst the older craftsmen were real artists, much of the same spirit remains to-day. The uncertainty connected with the making and casting of a mould, calls forth qualities which a merely mechanical operation, however intricate or clever cannot produce, and I wish to make an appeal to all interested in founding to cultivate and develop the artistic and imaginative side of the business, particularly amongst the younger men and boys.

At the present time, when everything tends to become automatic and mechanical, the art and craft of founding stands apart and refuses to be coerced, and it will be a long time before the complete making of a casting becomes a purely mechanical affair. It is granted that the production of certain types of castings lend themselves to mechanical methods, but we have not yet arrived at the stage where the skilled moulder is looked upon as out of date.

After a mould is made, there is the pouring or casting to consider, and it must always be remembered that a mould is tested by the actual pouring of metal. Many a nice-looking mould has been spoiled by the metal.

Recruiting Personnel.

Much has been said about the failure to attract boys into the trade. It is our duty to represent the trade in its true light. Though there are many objectionable features and much that is uncomfortable in the business, it is not at all sure that these things constitute the real reason why there are not more applicants for situations. We are paying the price of neglect in the past, due to influences both inside and outside the foundry, which were looked upon by the uninitiated as a place of evil reputation, of bad smells, and bad language, and to which a lad went when he could not get a job elsewhere, or as an accident.

Growth of Foundry Science.

We are suffering from a lack of imagination which originated 20 or 30 years ago, or probably longer, and about that period when the founding industry in this country touched its lowest depths socially, the minds of men were moving, as they ever do, towards higher things, and time and the need produced the men. So in 1904, nearly 23 years ago, we find a small number of men deeply interested in the conditions then prevailing and desirous of improving both the technical and scientific as well as the social side, meeting together to discuss ways and means, and from that meeting came the British Foundrymen's Association, which in fullness of time obtained a Royal Charter, and is now the Institute of British Foundrymen, an organisation which has done more to enlarge our vision and to re-create the craft than any other cause. Those of you who have studied the figures relating to the Institute will find that in 1904, the year of its inception, we had only 38 members. This year, 1927, we have a total of approximately 1,700 members, truly a creditable record.

We should remember that this is every foundryman's Institute, and not particularly our own. Every employer in this district should become alive to the value of this Institute as an educational school for foundry workers.

Managers and foremen should realise that it is their duty to encourage their likely men to join our ranks and gain the benefits of our meetings.

When we examine the improvement on the purely scientific side, the results are remarkable, and whilst a chemist, and particularly a chemical laboratory, were regarded as a luxury twenty years ago (and in many cases are to-day) we now regard them as being necessary to the regular and accurate production of castings metallurgically. The increased interest taken in metal mixing, sands and facings, and the information available, indicates the progress made. We are well aware that the laboratory cannot tell us many of the things we would like to know, and in many cases does not give the assistance desired; this is often due to the lack of practical experience on the part of the chemist, or to lack of appreciation and inability to use the information available on the part of the practical man. The lines of demarcation are, however, growing less, and both sides are being forced together in the common good of the whole.

Advance has also taken place in other directions. The increasing use of moulding machines, which has enabled us to maintain and increase production in spite of many adverse conditions, shows that the foundry industry generally is now alive to the advantages of machinery, particularly that type of machinery which makes it possible to obtain increased output with less fatigue for the workman.

Available Craftsmen.

The fallacy "that the introduction of machinery means the reduction of the number of skilled men employed" has been completely exploded in the foundry, and in normal times (present times being abnormal) the number of skilled moulders available is below requirements. What has taken place, and probably will do so to a greater extent in the future, is the grading of workmen, that is, the highly skilled moulder will do highly-skilled moulder's work, and those of lesser skill will do the less skilful work, and it will be possible to find work for them according to their ability.

The subject of training is a very difficult one, and as an Institute we must not forget that the future of the industry rests with the trained man, and no effort should be spared to induce the younger men in our ranks to undergo the necessary training and hard work which is essential to success. I should like to see a serious Paper written upon the "Training of Foundry Foremen." I am personally satisfied that the higher administrative positions in our foundries will be most satisfactorily filled by the highly trained practical men, rather than by the purely scientifically trained men.

From the few figures which I have given you, you will appreciate the growth of the Institute which has taken place, but we have not yet reached our highest desires. Considering the work done for the founding industry I do not think it unreasonable to put forward the suggestion that we ought to have at least one member in every foundry. When this is accomplished we shall be able to go forward to the attainment of many of the ideals for which this Institute stands.

The Chairman (Mr. Thornton) said members would be delighted to have Mr. Parker as their President for another year. The address, he hoped, encouraged all members to bring in new blood, and thus enlarging the sphere of influence of an already very valuable and active branch of the Institute. If members would do that they would greatly lighten the President's work.

Vote of Thanks.

Mr. R. D. Welford (Bradford) thought Mr. Parker, in an interesting survey, had brought out two outstanding features. One was the question of further education for the young men in the craft. There was little or no foundry work instruction in Bradford on an organised scale, and the same lack applied to many other parts of West Yorkshire. Leeds had some definite tuition, but even at Leeds he believed last session there had been only 15 students. Fifteen students meant only about one-tenth part of one youth engaged in each foundry, and it was utterly insufficient. Mr. Parker had also mentioned the question of definite training for foundry foremen. The foundry foreman to-day had to be metallurgist, mechanic, foundryman, and a host of other things.

Mr. J. C. Robinson (Halifax), seconding, said Mr. Parker's suggestion as to the need for organised training for foundry foremen and his suggestion of a paper on that subject was an excellent idea, and he (Mr. Robinson) hoped it would be taken up. About a fortnight ago the speaker had had the privilege of hearing the presidential address of Mr. Pemberton to the East Midlands branch of the Institute, and he idealised the hope that with further technical training, moulding would become a separate art from casting. Curiously enough, the President of the London branch had lately spoken on similar lines.

General Discussion on Foundry Matters.

Mr. A. S. Worcester (Huddersfield), opening the discussion, referred to close sands or sands for moulding, and suggested that by various mixtures, additions or subtractions, one could nearly always get a suitable sand. He supposed an average mixture, especially for heavy work such as was done in many West Yorkshire foundries, still contained a proportion of horse manure, which was getting more and more scarce with the increase of motor traffic, and it was becoming an expensive item. It would be interesting to hear if any member had a good substitute to suggest, and especially one which was better and cleaner.

There were still many men in the foundry who did not understand camber. Any job with a flat face and web must have the bottom face cold first. Only that week he had come across two instances in which men were cambering the pattern the wrong way. In ordinary ramming up of a job, Mr. Worcester thought there was often far too much energy expended on the work. He thought most foremen could show the men that they could ram far more effectively with less expenditure of energy and without the use of peg ramming. With solid chunks of sand the job could be made without a peg rammer.

Many craftsmen spoilt the shape of a casting in using small tools on big surfaces. Nine-tenths of disturbance of the face could be done away with by careful ramming. Another trouble, said Mr. Worcester, was the washing along of blacking, particularly on plates and wherever there was a good sweep of metal. He suggested dusting on of graphite after wet blacking. In dry sand work, the number of crushes to be seen in some shops on the joints was alarming, suggested the speaker. The edges of the jobs should be cleanly effected to avoid these, and it would save money. Dry sand work was a matter which had to be viewed from the points of view as to heavy or light work. On ordinary machine tool work he (Mr. Worcester) could turn out dry sand castings cheaper than green sand castings. Comparing sea sand-oil and compounds in core work, the speaker said in an ordinary foundry, where there was no

control over the heating, he thought a compound was better than an oil mixture. With linseed oil mixtures he thought one did not get the full benefit of the temperature of the oven.

Mr. Worcester proceeded to describe, and illustrate by rough sketches on the blackboard, a number of handy items of foundry tackle which he had found useful or had seen in useful occupation, and he suggested their more general use in the craft. These included templets, iron stakes, roller chains and beams and a very handy claw chain; a smoother running axle for core carriages; some mention of the rotary core machine; a three-way hook; an L for lowering cores in cylinder; and some comments on ways of improving the life of steel boxes. Mr. Worcester concluded by inviting experiences and information of members on the subject of rammed material or fire bricks for cupolas, and on the problem of avoiding hard holes.

Substitutes for Manure.

Mr. H. Forrest (Bradford) said he believed in Germany a good deal of flax straw was used, but of course it was very stringy.

Mr. H. Burnley (Bradford) said he had used sawdust with considerable satisfaction. The question of horse manure would certainly have to be faced as horses went more and more out of use in the towns. He thought there were a good many excellent substitutes. In the Bradford district for many years, especially for heavy castings, black sand was used largely. If the air could be taken from the face of the mould nothing was needed except that required to withstand the heat of the metal. If oil were put in the sand it simply burned away as soon as the metal got to it.

Mr. R. D. Welford (Bradford) said the question of using horse manure was a matter of increasing the permeability of the loam. Sawdust, if free from resin, was quite good, but if it was from mill there was a tendency for it to be mixed with bits of wood, and it meant a good deal of extra trouble in taking it out. Personally, he thought they could make satisfactory castings, without using manure, by employing sea sand or dry sand. Every foundry, of course, had its own particular mixtures of sand, and the mixture found suitable to one was not necessarily suitable to another. Whether it was merely a case of the introduction of a fresh mixture throwing the moulder out of his reckoning, he would not care to say. Personally, he thought black sand for dry-sand work was too friable unless there was a fair amount of wash in it, and that tended to close up the pores—which nullified the action desired.

Mr. J. G. Robinson (Halifax) said he assumed they all knew of these various things which could be used, but what Mr. Worcester was asking was for a suggestion of something which would overcome the growing shortage of horse manure, be cleaner to use, and do a better job, so that they could do away with horse manure altogether.

Mr. Welford: Fine chopped hay makes a good substitute for manure. It is more costly, but it is more hygienic.

Camber.

Proceeding to the questions of ramming, camber, peg ramming and flat ramming, the President said he had been greatly interested and rather amazed to see the piece-work in the pipe foundries at Falkirk. That had been on light castings and the methods there perhaps would not do for the more heavy casting work in West Yorkshire. There was, he believed, much to be said for peg ramming in heavy foundry work. In regard to camber, he thought that was largely a matter of seeing the pattern and the job and knowing the metal one was to use, before one could decide definitely what camber one could give.

Mr. Worcester said the point was, could anybody make a job with a web on either side, camber both ways? He thought it was impossible. The system of camber must be the same.

The Chairman said some moulders rammed a lot harder than others. The man's own weight on a job counted for something. Ramming up a camber face held the face of the job.

Equalised Cooling Eliminates Cambering.

Mr. H. Rowntree said he had had a fairly wide experience of camber. He found some lathe beds did not want any camber. It all depended on the structure of the pattern and the weight of shears at the bottom. He did not think ramming had much to do with it.

The Chairman: I am speaking of small castings, not large ones.

Mr. H. Sayers (Leeds) said the problem of camber was one of equalising the cooling. If that were done one got a better casting than by cambering.

Mr. Robinson suggested it was all a question of assessing natural phenomenon and allowing for differential cooling. The thick part which remained hot longest was bound to pull round the other way.

Mr. Worcester: Cast iron has got to stretch and the last-solidified will stretch the first-cooled.

In regard to cores, sands versus compounds, core machines, etc., Mr. Sayers said he had never found any difficulty in getting a core out. He put flour and linseed oil in.

Sausage Core Machines.

Mr. Watson said he had used core machines for fifteen years. He used a core oil and sea sand, and, in common with hundreds of others, had experienced no difficulty.

Mr. Worcester admitted it was not difficult to get good results when the foreman stood over the job for lengthy periods, but to obtain a standard mixture which would enable him to leave it in the hands of a labourer or a lad with the assurance the cores would be invariably satisfactory was not easy.

Mr. Robinson, referring to hard tap holes in cupolas, said much depended on the individual men. Text books, said Mr. Robinson, usually suggested that the bottom of the furnace should be made to taper a little, to incline towards the tapping hole, to drain the metal away before the bottom was dropped. Personally he thought that was wrong because by the time the metal trickled through it was likely to have set.

Lining Cupolas.

Mr. Worcester said there existed a furnace in the West Riding district which had been rammed up with only three inches of material instead of the usual, but which stood fire bricks up for three hours a day.

Mr. Welford said he was familiar with ramming a cupola, and he knew the case mentioned by Mr. Worcester which was only 3 in thick. That cupola had done very well, but had now been practically burned out. Mr. Welford said he believed he was the first to introduce two well known makes of plastic lining into use in Spain, and he found them better than fire bricks. In the patching the slag had to be chipped off first or the preparation would not stick. A very valuable factor in this kind of lining was that there were no joints in it. After it was rammed it needed venting a little. Of course, if one could get a very good brick and a very fine composition to join the bricks one got a very small surface between the bricks and no doubt results would be quite good, but in his own experience he thought he had better results from the plastic lining. He would not suggest that it was bound to be better in every case. If any member were in doubt on the matter he (Mr. Welford) could assure him that he need have no fear in changing over from brick linings to plastic up to a point above the melting zone, and have bricks higher. There was no difficulty in ramming. Plastic material was useful for patching in place of ganister, but it needed mixing the previous day and allowing to stand overnight so that the moisture permeated evenly through the material.

Mr. S. W. Wise (Bradford) Secretary of the Branch, said he had never tried a cupola with a plastic lining rammed up, but he had had some experience of patching with these materials. If Mr. Welford had had complete success in lining a cupola with the material his experience must be rather unique. His (Mr. Wise's) own experience in patching had been that this plastic material would not stand up as well as ganister. Mr. Welford had qualified his remarks by saying that if a man got "a good brick" he could have complete success with brick. Presumably no man would think of lining a cupola with anything other than good brick, or with other than thin joints. He would like to ask whether Mr. Welford, from his own experience, would prefer a first-class brick, put in properly, or a tip-top rammed-up plastic lining.

Mr. Welford: I would prefer the monolithic.

Mr. Wise said he had given it a good trial on patching and he had never found it so good as good ganister.

Mr. Forrest said in one instance he remembered a plastic lining being put in and it lasted only three days. Another plastic lining, however, lasted six months, but the linings gave much trouble and even the one that lasted the longer period cost, in the long run, probably twice as much as bricks would have cost, and for patching it cost more than Sheffield ganister.

Mr. Thornton, reverting to the question of sands, said there was a great deal in the actual moulding. There were jobs on which the men would insist on having manure, although they could do without it if it could not be got. He agreed with Mr. Robinson that the bottom of the cupola should not be tapered to the bottom of the tapping hole, but if anything just sloping it a little in the other direction, which obviated the hard tap hole.

Thanks to Mr. Worcester for his interesting opening of discussion were moved by Mr. Thornton, seconded by Mr. Sayers and carried unanimously.

Company Reports.

Babcock & Wilcox, Limited.—Interim dividend, 7 per cent., tax free.

Callender's Cable and Construction Company, Limited.—Interim dividend, 1s. per share.

Tweedales and Smalley (1920), Limited.—Interim dividend, 15 per cent. per annum, less tax.

Drake & Gorham, Limited.—Net profit, £9,586; brought in, £1,856; dividend, 5 per cent. for year; general reserve, £2,500; carry forward, £2,692.

Stothert & Pitt, Limited.—Loss, £5,814; brought in, £1,756; transferred from reserve, £7,500; preference dividend for year paid; carried forward, £249.

Samuel Osborn & Company, Limited.—Profit, £31,907; brought in, £3,602; available, £35,509; dividend, 5 per cent., less tax, on ordinary shares; carry forward, £9,423.

Ferranti, Limited.—Profit, £35,982; taken from taxation reserve, £20,000; brought in, £36,558; available, £92,540; dividend, 20 per cent., free of tax; general reserve, £35,000; carried forward, £36,020.

Neepsend Steel and Tool Corporation, Limited.—Profit, £25,419; brought in, £1,181; total, £26,597; interest on preference bonds, £4,128; writing off investments, £5,000; dividend, 3 per cent., less tax; reserve fund, £10,000; carried forward, £2,623.

Fairfield Shipbuilding and Engineering Company, Limited.—Profit, £48,986; brought forward, £90,630; total, £139,616; interest on first mortgage debenture stock, £11,250; interest on "A" mortgage debenture stock, £12,500; dividend on preference shares, £15,000; available, £100,866; dividend, 5 per cent. on ordinary (less tax); carry forward, £88,366.

United Steel Companies, Limited.—Directors are satisfied that company's loss arising in this year from coal stoppage exceeded £300,000, and have transferred that amount from reserves; brought to credit of profit and loss account, £57,148; brought in, £520,909; total, £878,057; deducting debenture and obligation interest, there is balance, £715,810; appropriated to "B" and "C" debenture sinking funds, £27,881; year's interest on preference shares of United Strip and Bar Mills, £96,000; losses of certain subsidiary companies for year, £119,912; surplus on profit and loss account at June 30, £472,016; dividend on company's 6 per cent. cumulative preference in arrear from January 1, 1922.

The report of Palmers' Shipbuilding and Iron Company, Limited, states that the depression in the shipbuilding, engineering and iron and steel trades continued through the period under review. At the end of the coal strike it was clear that the outlook for the company's products had much improved. A scheme of arrangement has been sanctioned whereby the debit balance has been written off the ordinary capital. The directors state that the company has secured important orders which have kept the works well employed. Two blast-furnaces and the company's ironstone mine were restarted in March last.

Buying Die Castings.*

By Charles Pack.

"Paper" Savings Sometimes Prove Costly.

The temptation of some buyers to show their company officials a paper saving on purchases is sometimes too great to resist. That buyer is not "true to himself"—he is acting contrary to the best interests of his company, and the results ultimately must prove fatal.

In this enlightened age of high business morals and business ethics it does not seem possible that any purchasing agent would deliberately place supply contracts based on a bid which he is certain is below cost and must of necessity entail a loss on the supplier's part. Nevertheless, contracts for die castings are placed where the purchasing agent knew that the price quoted did not cover the metal cost and was evidently based on an erroneous calculated weight. The purchasing agent who follows this policy may show substantial paper savings to his company, but in the ultimate analysis his savings are more than dissipated by express charges, duplicate die charges, follow-up expenses, additional plant operations, inferior product, and all of the other attributes of and corollaries to an undependable source of supply.

The buyer of die castings must act as an intermediary between the engineering department of his own company and that of his supplier. The intelligent buyer will have at his command his supplier's trained engineers and metallurgists who generally are more thoroughly versed in the art of die casting than are his own engineers. With the assistance of this outside engineering talent the buyer is able to make many recommendations to his plant engineers that invariably result in substantial reductions in costs. The buyer who will establish such a contact with dependable sources of supply, and deal with his suppliers on a fair and equitable business basis, will always buy the best product and ultimately at a minimum cost.

It is a pleasure to acknowledge the fact that the great majority of successful buyers encountered do business on this basis. The number of purchasing agents who buy die castings on the "catch-as-catch-can" basis are in the very small minority, and it has been observed that they do not "catch" as often as they are "caught."

Usual Procedure in Buying Die Castings.

In large plants where separate engineering and purchasing departments are maintained, confusion and costly delays are often encountered due to the buyer's inability properly to analyse his bids on die castings. For instance, the engineering department designs a part and submits blue prints of this part to the purchasing department for bids on die castings. In the absence of any information to the contrary, the engineering department assumes that the supplier will deliver castings as per blue print. The purchasing department sends these blue prints to its suppliers with requests for bids. The department supplier will carefully examine this blue print, since to him it represents the requirements of the engineering department. Often the supplier will find limits specified by the engineering department that are too close to maintain in the casting operation, or holes and threads specified that cannot be cast. He may also find it necessary to recommend the elimination of undercuts, necessary tapers, drafts, etc. It is customary for the supplier to assume that these changes are permissible and bid on this basis. The conscientious supplier will make careful notation on his bid of the points noted.

When bids for die castings are received by the buyer he should carefully read any notes that may accompany the bid on each part. Invariably the buyer will find it advisable to submit the supplier's comments to his engineering department for its guidance.

Some buyers, on receiving bids, simply compare prices and disregard any accompanying comments. This practice invariably results in confusion and delay when samples are received, since the samples do not correspond with original blue prints, often requiring additional operations, which the buyer's engineering department has not planned for. To avoid any possibility of misunderstanding, confusion or delay, the buyer should insist that the die-casting supplier submit a blue print before starting on the die, showing exactly how the supplier expects to deliver the part. The buyer can then submit this blue print to his engineering department, and, if approved, he can instruct his supplier to proceed, secure in the knowledge that this item has been disposed of in a satisfactory manner.

Some suppliers of die castings have adopted the policy of bidding on the basis of supplying castings "uncleaned." This may sometimes be hidden in an obscure section of the proposal. Die castings, as they come from the die, will have attached metal "fins," vent flashes, gate runner, ejector pin flshes, etc. By "uncleaned" is meant that the castings will be shipped by the supplier as they come from the die, and the purchaser must remove these fins, etc. This often constitutes an appreciable item of cost, and in the purchase of die castings the buyer should know definitely just how much work his plant will be required to do on these castings to make a satisfactory product.

Necessary Information.

In asking for bids on die castings the buyer will find that bids will be more dependable if he will supplement his request for information with as much data concerning the part as he can possibly obtain. The following information is essential to an intelligent bid:—(1) Application of part; (2) service conditions; (3) present method of manufacture; (4) material now used, if satisfactory; (5) surface finish required—if plated, polished or enamelled; (6) approximate yearly requirements.

Buyers should bear in mind that the quantity to be produced represents one of the most important factors in the cost of die castings. They will find it more economical to buy six months' or one year's requirements than to make small monthly purchases.

The buyer should bear in mind that, when placing an order for a die to produce a new part, he is buying something that he does not see and is depending on the supplier to design and construct this die so as to produce the most satisfactory results. It is self-evident that the reliability and experience of the supplier should be carefully considered by the buyer before placing an order. Some buyers, doubtful of the reliability of their source of supply, believe that by stimulating their right to remove the die, they have fully protected themselves. In actual practice this procedure proves futile for the following reasons:—

In the production of any die-cast part the design and construction of the die are very important factors. Very often there are fundamental things to be considered that, if overlooked, will result in a die that cannot produce a high-grade product.

The buyer should bear in mind that fundamental mistakes in die design often cannot be corrected unles the new die is constructed. Furthermore, the type of die designed by any supplier will depend to a large extent upon the particular type of casting machine used by this supplier. Very often such die is of no value to a competitive supplier.

Why Dies Should Remain with Supplier.

Die-casting manufacturers usually stipulate that the dies must remain in their possession, and while some buyers take exception to this practice, it is based on sound business ethics. When the principles underlying this rule are understood, buyers seldom object to this practice. These priciples are:—

(1) Dies are estimated at cost. As a matter of fact, every large die-casting plant shows a substantial loss in costs of die construction at the end of each year. For one company to take a loss in constructing tools and then permit another competing company to profit by the use of these tools is not in accord with sound business principles.

(2) All the engineering talent and experience of a die-casting company are represented in the dies constructed by that company. It would be manifestly unfair to transfer that die, with the trade practices represented by it, to a competing company which has not been called upon to pay for this experience.

(3) The composition of the steel used in die construction is a vital factor in the life of such dies. Progressive die-casting manufacturers maintain chemical laboratories and are constantly experimenting with die materials. To transfer a die and disclose this vital practice to competitors is not in accord with the best business principles.

(4) If the die-casting manufacturer did not retain possession of the dies produced by him, it would permit his competitor to underbid him after the former had worked out the "kinks" on the job and brought it up to maximum production. The latter would take over good working dies and cleaning tools with the engineering knowledge represented by them, taking full advantage of that knowledge and experience without any cost to him. On this basis the progressive manufacturer is at a disadvantage, the incentive to improve the process is penalised and the die-casting industry must of necessity suffer.

In conclusion, it should be emphasised that experience with purchases of die castings has shown that the most successful buyers adhere to the following procedure:—

Carefully choose one or two dependable and reliable sources of supply. Put your die-casting problems squarely up to these suppliers. Do not attempt to tell your suppliers how to construct the die or what alloys to use. Assume that your supplier knows more about die castings than you do. Tell him what results you want and let the supplier do the rest. If the supplier is progressive and conscientious, you will never have any trouble buying die castings, and although you may not buy cheap die castings, your ultimate die-casting costs will be lower than if you buy on the haphazard hit-or-miss basis.

* Extracted from "The Iron Age." The Author is Vice-President and Chief Chemist and Metallurgist of the Doehler Die-Casting Co., Brooklyn.

Publication Received.

Graphite Electrodes.—The Electrical Equipment & Carbon Company, Limited, of 109, New Oxford Street, London, W.C.1, have sent us an eight-page booklet describing the technical achievements of a German make of graphite electrodes. There is no British manufacturer of this type of electrode and for many years the business has been an American monopoly. We note a consumption claim of 5.5 kilos. per ton of steel melted. Our own personal record is 2.2 kilos. when operating a furnace in Italy. That is, however, more a question of furnace practice than electrode quality. We have not yet had the opportunity of inspecting this type of electrode, but apart from the electrical properties, certain mechanical attributes are desirable; for instance, the joints must be a machine fit. The electrodes must be perfectly parallel, otherwise stresses are placed on them which they are but ill-fitted to withstand. These should have been emphasised in the pamphlet instead of devoting so much space to developing a case against the amorphous variety, which possess the sole advantage (when full-size) of protecting the roof from direct radiation from the actual arc. The pamphlet is available on request from our readers.

The American Ceramic Society is to visit Europe next year. They are including the Potteries and Glasgow, as well as most of the Continental centres.

Direct Castings.—It is stated that in Germany, both the Thyssen and Mannesmann works are pouring certain castings direct from the blast furnace. Technical difficulties have been overcome, and 17 per cent. is said to be saved as a result of eliminating the cupola.

Notes on Rate of Cooling and Casting Temperature.

(PART I.)

By Our Metallurgical Correspondent.

The influence of rate of cooling and casting temperature in the successful production of castings is receiving renewed attention on the part of foundrymen. The knowledge of the importance of these influences on both the behaviour of the liquid metal poured into the mould and also the final properties of the casting is frequently regarded as the result of comparatively modern observation. This is by no means true, and this knowledge has been possessed probably by foundrymen from the very earliest times. The descriptive article on Brass-founding, by that early philosopher, physician and scientist, Galen, in Volume V of the Proceedings of the Acadamie

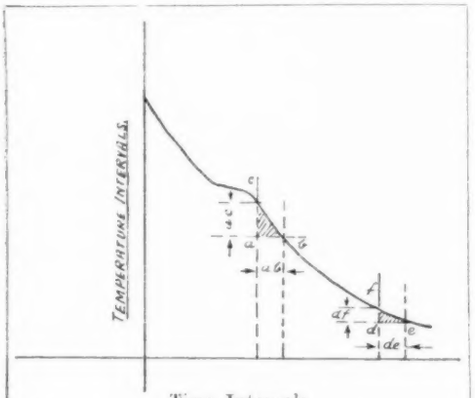


Fig. 1.—Cooling Curve (Diagrammatic).

Royale des Sciences, printed in 1764, contains the following passage:—"Work in a foundry demands continual care in order to feed the fires and maintain the necessary degree of heat for casting."

In the same volume Duhamel de Monceau states that "the founders learn by long practice to care for the fires of the furnace, and to know when the material is in proper fusion and ready for casting."

Benevenuto Cellini, in his descriptive manual, tells us in very quaint language of the ineptitude of his assistants in this matter of "proper fusion" or casting temperature. The failure of an important casting due to this cause is faithfully depicted, as is also Benevenuto's method of acquainting his assistants of his displeasure.

During the past twenty-five years attention of our investigators has been devoted to the evaluation of this influence of casting temperature on the various physical properties, and these efforts to discover the quantitative effect of both casting temperature and rate of cooling form the basis of modern observation in this connection. It is this aspect of rate of cooling and casting temperature to which the attention of foundrymen and engineers is continually being redirected. The study of the manner in which molten metal cools and solidifies and the influence of what might be described as the varying thermal conditions forms the most fascinating study, in addition to the most important study, in metallurgy.

Rate of Cooling.

It is well known that castings of large cross-sectional dimensions take much longer to cool than castings having correspondingly smaller dimensions. This observation is interpreted by the foundryman as indicating that the rate of cooling is slower in the former case than in the latter case. In other considerations of rate of cooling this phrase is associated with a perfectly definite conception, and if this is carefully considered we find that the broad conception embodying this phrase, as commonly used by foundrymen, is, strictly speaking, wrong. The error in this conception and interpretation broadly stated above arises out of the use of the phrase, "rate of cooling," which is a somewhat different notion from that of "the total length of time in cooling."

The rate of cooling may be strictly defined as the ratio of the total change in temperature occuring in a given time to that time, or more simply the fall in temperature per unit time. Since this ratio is variable even in a freely cooling body it is necessary to consider it in respect to the smallest convenient unit of time. In this respect the notion of rate of cooling is different from that of the total length of time in cooling, which fails to take into consideration the variation in the rate of cooling during the total time interval.

This difference between the two notions is exemplified by reference to the fact that all molten alloys in cooling to the solid state pass through at least one stage where the rate of cooling is zero or approximately zero. In other words, the cooling is actually arrested for a period. On either side of such arrest periods the ratio of fall in temperature per unit time might conceivably vary considerably without influencing the total length of time in cooling. Apart from this it is a matter of observation, and it can be shown that in a freely cooling body the ratio of the fall in temperature per unit time, or the rate of cooling becomes progressively slower as both time and temperature elapse. The observation of these facts and their co-ordination we owe to Sir Isaac Newton, who embodied them in his celebrated law of cooling. This law states that in a freely cooling body the rate of cooling is proportional to the *excess* of temperature of the body over its surroundings.

Relation Between Temperature Fall and Elapsed Time.

In a freely cooling body, apart from the special arrests or intervals referred to above, the variation in rate of cooling as the mass cools is of a uniform nature. The careful observation of the cooling is a familiar feature in the investigation of metals and alloys, and the fall in temperature is carefully observed at consecutive short intervals of time. When the results obtained from such observations conducted on freely cooling masses are plotted, a cooling curve is obtained which illustrates very clearly the relation between the fall in temperature and the elapsed time. A diagrammatical example of such a curve is shown in Fig. 1, in which the temperatures are plotted along the vertical axes and the time intervals along the horizontal axes. This example is typical of the curve obtained for a pure metal cooling from the liquid state and clearly represents the relation between the fall in temperature and the elapsed time. Let us imagine a small interval of time at any instant during cooling, represented by the distance *ab* measured along the horizontal axis. The fall in temperature during this interval of time is obtained by drawing the vertical line *ac* till it intersects the cooling curve. The rate of cooling at this instant is then obtained by virtue of our definition as the ratio *ac* deg. C. per sec. It will be seen that this ratio is determined by the slope of the curve at any instant of time, for if we examine another interval *de* and *df* we see at once that at this instant the rate of cooling expressed by the ratio *df* is different and smaller in magnitude than the previous ratio. This decrease in magnitude of the rate of cooling as the temperature falls or as the time elapses is common to the cooling curves of all freely-cooling bodies. It is uniform and is logarithmic in character. In other words, the decrease in magnitude of the rate of cooling is proportional to the rate of cooling itself. It is possible, under carefully-defined conditions to calculate the form of these cooling curves by the application of the Fourier system of mathematical analysis. This has been done in certain cases and the results obtained show a remarkably close agreement with the actual results determined by experiment. (See McCance, J.I.S.I., 1916, No. 1, page 51, also Portevin and Garvin and McCance, J.I.S.I., 1919, No. 1, pages 497 and 560).

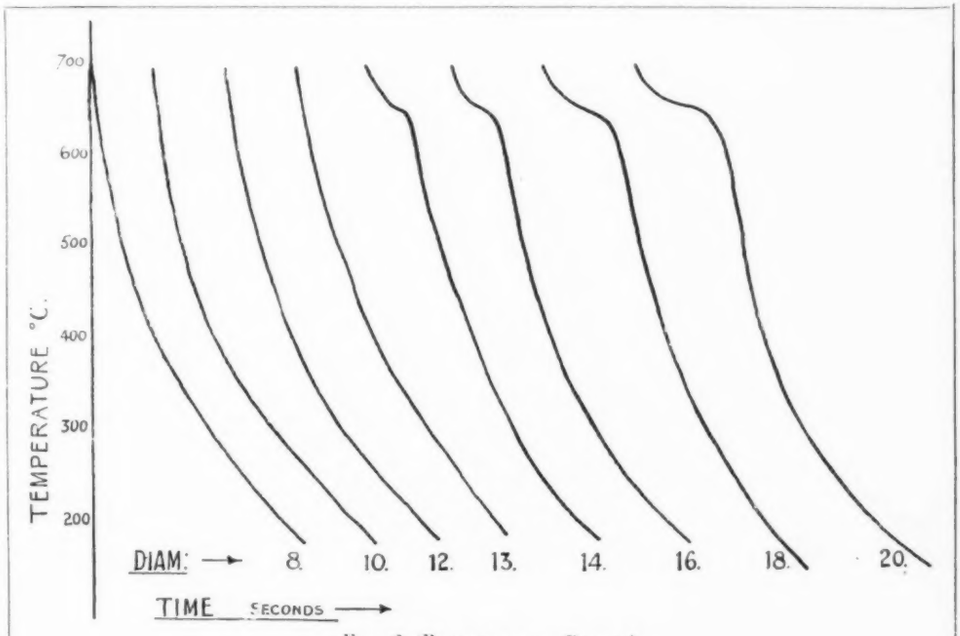


Fig. 2 (Portevin and Garvin).

We note, therefore, that in all cases of freely-cooling bodies the rate of cooling becomes uniformly slower as the temperature falls or as the cooling progresses.

Internal Behaviour of Rate of Cooling.

It is now of interest to consider how the rate of cooling behaves in the interior of a mass of cooling metal. Again, it is a matter of common observation to foundrymen that the surfaces of a mass of cooling metal adjacent to the walls of the

container solidify before the internal portions. More accurate observation by taking cooling curves at regular intervals across the section of the cooling mass shows that the rate of cooling at any instant of time becomes increasingly slower the further away from the cooling surface and also that at any particular temperature during cooling the rate of cooling is proportionately slower as the interior of the mass is approached. These facts can in a like manner be deduced from the fundamental Fourier conception of the conduction of heat. Whilst these facts are, of course, only a restatement of the foundryman's common observation, it is very important that they should be carefully understood in this manner. Arising out of this phenomenon of the variation in rate of cooling across the section of a mass of solidifying metal practically the whole of the metallurgical troubles of the foundryman arise. It is a most important result of this consideration, that the rate of cooling varies as the temperature falls and also within the mass of the cooling body. Strictly, the rate of cooling can only be spoken of in relation either to a particular temperature or time, or a particular point within the cooling mass.

Critical Points.

The interruptions in the smooth direction of the cooling curves corresponding to the point or range of temperature at or over which solidification occurs in the cooling down of a liquid metal have already been referred to. These interruptions or arrest points, as they are termed, indicate either a marked slowing up or a total cessation in the cooling at their particular temperatures. This partial or temporarily complete cessation of cooling is due to the liberation of latent heat within the mass as a result of the

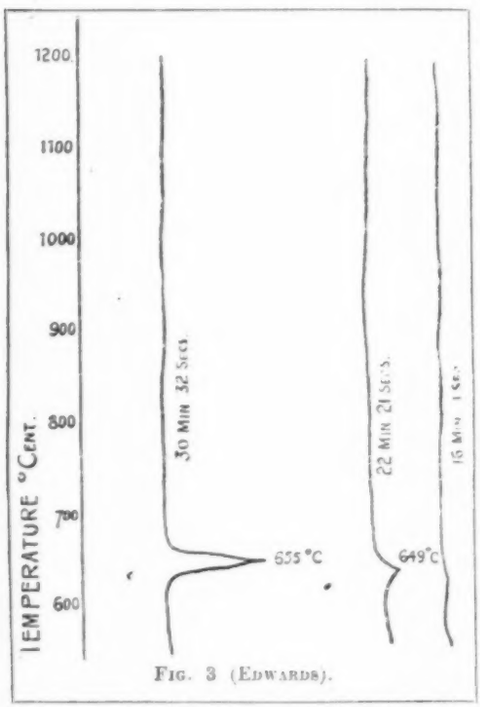


Fig. 3 (Edwards).

physical change occasioned either by solidification or the formation of a new phase or constituent. In an alloy like cast iron several of these interruptions are experienced corresponding to the various changes.

One of the most important features of certain of these changes in which we are interested is the possibility of their complete suppression under conditions of very quick cooling. This phenomenon is very familiar in connection with the hardening of steel by quenching in water, and it is obvious that the character of the final alloy is profoundly influenced by the effect of the cooling on the various changes which would normally occur in the solidification of alloys.

Increased Rate of Cooling Lowers Critical Points.

The effect of the rate of cooling on the changes taking place in the cooling of steel was first shown by Osmond, who demonstrated the lowering of the temperatures at which these changes, or the transformation points occur in steel with increased rate of cooling. This subject has been more fully investigated with respect to steels by Benediks, Le Chatelier, Portevin, Edwards and others. The effect of increased rapidity of cooling in lowering the temperature of the transformation points in steel has been shown by Portevin to be subject to a discontinuity. This has led to the conception of a critical rate of cooling which is carefully defined by Portevin. In this connection and in this conception the rate of cooling is defined between much wider limits of temperature than indicated previously in these notes—and in fact the rate of cooling is defined as the time which elapses during the passage between the temperature interval 700-200 deg. C. This method, with a slight difference in the temperature limits, has been followed in other investigations. The critical cooling rate referred to above refers to the time elapsing between the above temperature limits, and may be considered as that rate of cooling at which the evidence of the transformation undergoes a marked change in character illustrated by the following cooling curves. The curves illustrated in Fig. 2 are a series of average curves taken experimentally by the ingenious method devised by Portevin. They consist of the average cooling curves taken at the centres of geometrically similar cylinders of steel containing 1.07 per cent C and 0.08 per cent. Mn quenched in water. The curves are numbered in reference to the increasing diameters of the samples and the quenching was carried out from approximately the same temperature in every case. The full details of the curves are supplied in Table I.

Table I.—*Results obtained from Quenching Bars of Increasing Diameter.*

Diam. of samples. Mms.	No. of curve in Fig. 2.	Rate of cooling seconds over range. 700 to 200 C.	Temperature of arrest visible on curve.	Chief constituent.
8	1	4.4	—	Martensite.
10	2	5.5	—	,,
12	3	6.2	—	,,
13	4	6.6	—	,,
14	5	6.9	635	Martensite. and Troostite.
16	6	8.0	655	Troostite.
18	7	9.2	665	,,
20	8	10.3	665	,,

The effect of varying rates of cooling in a steel containing 6.15 per cent. chromium and 0.63 per cent. carbon over a temperature range of from 1,230 to 550 deg. C., has been strikingly demonstrated by Kikkawa and Edwards. The cooling curves illustrated in Fig. 3 are taken from this investigation and clearly show the progressive lowering of the carbide change point until the "critical cooling velocity" is attained, when the carbide change point is conspicuous by its absence.

It is a matter of considerable interest to note that in the case of the carbon steels investigated by him, Portevin was able to show that the suppression of the change point at the critical cooling rate was accompanied by an alteration in the law of cooling in the lower ranges of temperature below the change point. This alteration takes the form of a diminution in the gradient of the curve at the lower temperatures, indicating a slowing up in the rate of cooling. The character of this diminution in the gradient is clearly illustrated in the curves given in Fig. 2. It is very natural to infer that this slowing up of the rate of cooling is caused by the slower and prolonged liberation of the heat which would otherwise have been liberated at the temperature of the change point.

Influence of Composition on Critical Points.

The critical rates of cooling or quenching are influenced by the chemical composition, and also by the initial temperature of the quenching. The effect of the composition of steels on this phenomenon is outside the scope of these notes. In so far as the influence of the initial temperature is concerned, on *a priori* grounds we can be certain that this will influence these phenomena by reason of (1) its influence on the rate of cooling, and (2) its influence on the initial state or constitution of the alloy.

This aspect has been investigated in relation to steels. In the research by Edwards, previously referred to, in connection with chromium steels the effect of the initial cooling temperature on the Brinell hardness, was investigated. A marked increase in this value was found to occur at a point coincident with a certain initial cooling temperature. Portevin and Garvin were also able to demonstrate that with an increase in the initial temperature of quenching the rate of quenching was increased, and the phenomenon of the lowering of the transformation point was likewise affected.

Undercooling or Surfusion.

Undercooling, superfusion or surfusion, as it is variously referred to, relates to the arrest points

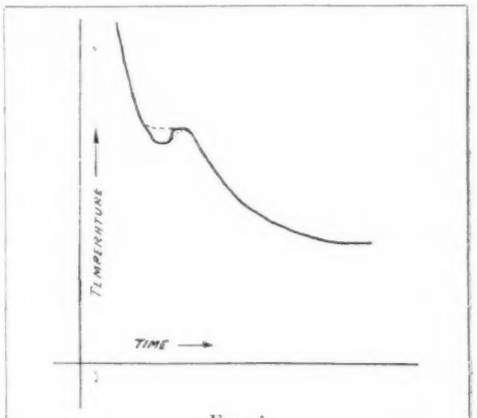


Fig. 4.

on the cooling curves of liquid alloys cooling down from the molten state. Under certain conditions in the cooling down of molten metals and alloys the temperature of solidification is passed without the accompanying change of state of the liquid to the solid. At some temperature a few degrees below the actual solidification point, solidification commences, and the sudden liberation of the latent heat raises the temperature of the mass for a small interval of time either up to or close to the actual solidification temperature.

This phenomenon was noticed by Fahrenheit in connection with the freezing of water. It makes its appearance on correctly recorded cooling curves in the manner shown diagrammatically in Fig. 4. The arrest in such curves corresponding to the solidification point does not commence until a few degrees below the true solidification point as indicated by the dotted lines. The subsequent liberation of the internal heat raises the temperature in the manner indicated.

This phenomenon is largely affected by the rate of cooling, and is very commonly associated with rapid rates of cooling. It is a phenomenon that has to be carefully guarded against in the accurate determination of the solidification temperatures of metals and alloys.

(To be continued.)

B.S. Specification for Round-Strand Steel-Wire Ropes for Cranes.—The British Engineering Standards Association has just issued a specification (302-1927) for round-strand steel wire ropes for cranes, which has been prepared by Committees representative of both the buying and manufacturing interest. Recommendations are given in the Foreword for the guidance of designers and users. Copies can be obtained from the B.E.S.A., Publications Department, 28, Victoria Street, London, S.W.1. Price 2s. 2d., post free

Correspondence.

Corrosion by Oil.

To the Editor of THE FOUNDRY TRADE JOURNAL.

SIR,—In your issue dated 20th inst. you were kind enough to give an abstract of above Paper. It is important for readers to know the exact position, and with your permission I would make it clear.

In the first place, service oils *which had passed all the usual tests applied by chemists* were by the new D.O.C. test found to be distinctly corrosive, and were proved to have caused immense damage on two motor ships.

Following this discovery, many oils taken from the lubrication systems of ships, motor cars, and so on have been subjected to the D.O.C. test, and not a few of them have been found to be corrosive to steel or whitemetal.

This means to say that "wear" is due frequently to the combined effects of rubbing *and* corrosion. It sheds a new light upon problems connected with wear of cylinders, cylinder liners, and all bearings. These problems to-day are most perplexing, and becoming increasingly vital in the newer forms of internal-combustion engines, no matter whether they be using heavy oil or light spirit. Wear tests on wear-testing machines have not proved particularly useful, and in the light of this new knowledge the fact is not so surprising as it previously appeared to be.

Engineers and chemists considering any question of wear need to look deeply into the question of whether a great deal of it is not due to corrosion.—Yours, etc.,

HORACE J. YOUNG, F.I.C.

3, Central Buildings,
Westminster, London, S.W.1.
October 21, 1927.

Works Material Exhibition in Berlin.

To the Editor of THE FOUNDRY TRADE JOURNAL.

SIR,—I have just had the pleasure of going through this exhibition, and consider that anybody who can afford the time and money, would find the outlay well spent.

It is an educational exhibition—not a sales exhibition—something quite different, and more like a large laboratory, testing house, university, etc. Everything seems to be there, except the names of the makers, and it speaks worlds for the manufacturers that they have swallowed their individuality for the common good of the industry.

Iron, steel, Alloys—in castings forgings and the wrought state, such as sheets, etc., are all there, showing how it should, and how it should not be done.

If one requires names, etc., of makers, one is referred to a special department, where such information can be secured. The exhibition fills a space like Olympia.

It would pay our authorities, Iron and Steel Institute, and other kindred associations to pay for some competent gentleman to come out and and report for the benefit of the whole. The exhibition lasts till October 13.—Yours, etc.,

H. SHILLITOE.

Berlin,
October 24, 1927.

Standardised Costing.

To the Editor of THE FOUNDRY TRADE JOURNAL.

SIR,—The subject of the leading article in THE FOUNDRY TRADE JOURNAL this week—"A Possible Way Out," once again raises the important question as to the desirability of forming some kind of a committee with the object of establishing, if possible, some kind of a standardised costing system.

If such a system could be formed, the next, and probably most difficult, move would be to get it adopted by the majority of founders.

I think it could be done in time, and would undoubtedly make a considerable difference to the prosperity of iron founders in general.

The whole question would have to be settled by the Institute of British Foundrymen, and personally I should be pleased to give any help I could.

A committee of this kind would necessitate a good deal of work by members, and I do not suppose anything useful could be done unless they were willing to meet, say, once a month, for probably a period of 12 months at least.—Yours, etc.,

A. W. G. BAGSHAWE.

Dunstable Works, Dunstable, Beds.
October 21, 1927.

[It is scarcely the work of the Institute of British Foundrymen to do more than to outline what it considers to be a satisfactory system of wide, if not universal, application, as any extension beyond this point would not be in harmony with the terms of its Royal Charter. We consider that the matter could be best tackled by (1) The drawing up of a majority and a minority report by each section of the Institute; (2) the presentation of these reports to a meeting specially called for the purpose; (3) the production of a final report which would be sent to every employers' federation treating with foundry conditions, recommending that they by the fullest utilisation of existing organisations do their utmost to impose it upon the industry in general. This method would allow all foundrymen to interest themselves at every stage of its development. This has been done in Germany with outstanding benefits to their industry.—ED.]

A Successful Venture.

For some time the Scottish Branch has had under consideration the question of forming a Junior Section of the Institute, and arrangements have now been advanced a stage further. On the invitation of the directors of Messrs. G. & J. Weir, Limited, a visit was paid to their Cathcart Works last Thursday, when the inaugural meeting of the session was held.

The sympathetic support of the various foundry employers in Glasgow and neighbourhood had been enlisted in the proposed section, and by means of letters, posters and postcards every effort was made to give the meeting wide publicity. The success of those efforts was made manifest when applications were received from 340 boys for tickets for admission. This number was very greatly in excess of that expected, but Messrs. Weir readily altered their arrangements from day to day as the list of applications grew.

Fully 300 were present at the visit, and in a series of groups they made a round of the pattern shop, iron foundry, brass foundry, monel rolling mill, testing machine room, and the schoolroom. In each department men who are experts on the various machines and processes were present to give demonstrations for the benefit of the lads, and after the round had been completed the groups were conducted to the canteen.

Here Messrs. Weir had tables spread and the boys were entertained to tea to the accompaniment of a musical programme. From the rapidity with which the plates were emptied, it was evident the boys believed that the operation of "feeding" was an essential one for every apprentice to practice.

After tea, Mr. Makemson, General Secretary, gave a very interesting account of how other sections had been organised and conducted, and expressed the hope that the new section would soon be in full working order. He stressed the advantages of works visits, and hoped these would form a feature of the sessions arrangements.

A motion, submitted by Mr. Longden, that a section be formed was carried by acclamation, and Mr. Norman C. Blythe, 10, Dane's Drive, Scotstoun, was elected Secretary. Mr. Longden also proposed a vote of thanks to Mr. Makemson, and this was enthusiastically given.

The meeting terminated with a cordial vote of thanks, proposed by the Branch President, Mr. Thomas Bell, to the Directors of Messrs. Weirs, and to Mr. Aitkenhead, Works Manager, for the kindness of their invitation and hospitality, and also to Mr. Packer of their apprentice training department, who had charge of the arrangements in the works.

Catalogue Received.

Moulding Machines.—The Universal System of Machine Moulding & Machinery Company, Limited, of 97, Queen Victoria Street, London, E.C.4, has sent us a copy of their new catalogue, which illustrates and describes a very complete moulding range of machines made by their principals, Messrs. Bonvillain et Ronceray, of Paris. Initially a psychological mistake has been made by beginning with the "Conditions of Sale," as obviously the first effort in any catalogue should be to obtain the maximum amount of interest in the economic advantages to be derived from the use of the material or plant set out in the body of book. We suggest that in the next edition, page 68—the last one—outlining the contents of the book should be transposed with the "Conditions of Sale." Surely this would be more logical.

The contents are really interesting, and show a real knowledge of the multifarious requirements of the industry. The very interesting method of making pattern plates without invoking the aid of the machine shop is indicated and its results illustrated. Following this are descriptions of the simpler types of moulding machines, such as those worked by a hand lever or foot pedal. The first addition is that of the roll over action. These machines are usually supplemented by installing nearby an assembling and pushing out machine.

To power machines the major space of the catalogue is devoted, starting off with the simplest type "A," but even this admits of modification by the addition of an underneath ramming "gadget." To some extent type "E" has superseded that previously described, the whole of the pressure being upward, and so eliminating any possibility of water dropping on to the mould. Type "M" is a further modification, having a table which can be varied in shape to suit complicated requirements. A further type—"C"—is designed to deal with pattern draws longer than normal.

In the "R" series of machines the entire moulding part of the apparatus is completely rolled over in order adequately to strip moulds incorporating heavy cods of sand hanging away from the joint line and the like. Some of these, such as the RC1 and RC2, are of considerable dimensions, and are capable of handling really large work.

Though their reputation has been built up on hydraulic machines, this firm has of late decided to enter the jolt ramming sphere of activity in order to complete their range of usefulness to their clients. For its actuation a combination of hydraulic and electric power is used.

One cannot but get the impression that of all the machines illustrated in the catalogue the ones of which this house is most proud are the types "F" 5 and "DF," which simultaneously ram the top and bottom moulds. They are designed for the rapid production of shallow moulds and dispense with the necessity of moulding boxes. They call for the use of what has become to be known as the "down sand frame." This section of the catalogue (page 38, *et seq.*) is, by the way, much better laid out and illustrated than the balance, especially page 41.

An interesting claim is made on page 46, when dealing with the "AF" type of machine, which insists that hand-moulded stove plate work can be "beaten" by its employment. If this can be generally substantiated it will mean that the last stronghold of hand moulding has at last succumbed to the attack of modern machine methods.

The last technical section is devoted to hydraulic power, and details are given of the pumps and accumulators specially manufactured for use with moulding machines. The last ten pages illustrate important installations of the machines previously described.

The catalogue is extremely businesslike, and for every machine described there appears a table giving pertinent commercial and technical data. The catalogue is very profusely illustrated with 72 pictures.

Trade Talk.

The Consett Iron Company, Limited, have partially demolished one blast furnace at Consett, Co. Durham.

The Cargo Fleet Iron Company, Limited, have an order for 1,200 tons of steel tramway rails for Edinburgh.

The Dalmellington Iron Company, Limited, who have given up the manufacture of pig-iron, are now demolishing their blast furnaces at Dalmellington, Ayrshire.

Mr. I. Shapin, carrying on business as the Penton Engineering Company, of 15, Cromer Street, Gray's Inn Road, London, ball bearing specialist, has been adjudicated bankrupt.

An order for twenty tank locomotives for the London and North-Eastern Railway has been placed with R. & W. Hawthorn, Leslie & Company, Limited, Forth Banks Works, Newcastle.

Messrs. S. Murgatroyd & L. Hargreaves, machine tool makers, National Works, West Lane, Keighley, trading under the style of Murgatroyd & Hargreaves, have dissolved partnership. Mr. L. Hargreaves will continue the business under the old style.

The Sheffield Society of Engineers and Metallurgists opened a new session on October 17, when Dr. A. G. C. Gwyer, of the British Aluminium Company, Limited, Warrington, lectured at the Mappin Hall on "The constitution and properties of some aluminium alloys." Professor C. H. Desch (president of the Society) presided.

The goodwill of the old-established firm of Stedman, Crowther & Company, metal merchants, of London, Liverpool, Manchester, Birmingham, Leeds, Glasgow, and Newcastle-on-Tyne, has been acquired, and the business has been formed into a private limited company under influential and strong financial support. The new company has retained the services of Mr. F. G. Martin.

In order to provide for the development of the company's business, the directors of Parker, Winder & Achurch, Limited, have taken steps to increase the nominal capital of the company to £120,000 by the creation of 60,000 new ordinary shares of £1 each. Of these shares it is proposed to issue immediately 43,000, and existing ordinary shareholders will have the right to subscribe for one new share for every existing share held. This offer will absorb 38,000, and the balance of 5,000 is to be reserved for issue on special terms to the staff.

For some time the demand for tin from the Welsh tinplate areas has been disappointedly small, and Continental requirements have been restricted. Stocks of the metal are by no means large, but the probability exists that they will be augmented a little each month until the end of the current year, at least. The weakness in the metal market has naturally reflected adversely on the shares of producing companies. An extraordinary report has appeared in the Press in regard to an alleged meeting of tin producers. The report was to the effect that certain of the tin producers met in London on October 14, with the object of discussing plans whereby the price of tin may be controlled and saved from the rather severe fluctuations which have caused difficulty for consumers of tin. While no definite information is available it is quite safe to state that such a scheme has not the slightest chance of success.

The Cumberland blastfurnacemen and iron ore miners are considering the question of amalgamation, and a meeting to discuss the matter and, if possible, further this object was held at Egremont, addressed by Mr. Thos. McKenna, general secretary of the National Union of Blastfurnacemen; Mr. Ambrose Callighan, of Workington; and Mr. T. Gavan Duffy, secretary of the Iron Ore Miners' Association. Mr. McKenna said this matter had been under discussion between the council of the Iron Ore Miners' Association and their executive for a matter of two years, and ultimately they were authorised by resolution of the iron ore miners' council to proceed with the question of amalgamation. There was clearly a natural affinity between the two unions. They had affiliated with their union the quarrymen of West Cumberland. Now they wanted to complete the industrial ring by associating themselves with the iron ore miners. With a combination of furnacemen, ore miners, and quarrymen, they would complete the industry. Mr. T. G. Duffy (secretary of the Cumberland Iron Ore Miners' Association) stated that he would be retained in an advisory capacity; the question of workmen's compensation would largely remain in his hands, and the Conciliation Board with its wages scale would remain intact. A similar meeting was held at Millom, when a resolution in support of amalgamation was carried. It is understood that a decision can only be arrived at by ballot.

In regard to copper statistics, the feature in the home returns has been the considerable encroachment made upon the supply of rough bar material which, at the end of September, amounted to 15,540 tons, and it is rather expected that further withdrawals will be made from warehouses this month, judging from the keen demand which has sprung up lately for cash warrants on the part of large dealers. The difference in the value between standard and electrolytic copper was for weeks past abnormally wide, and the comparative cheapness of the former has evidently stimulated buying for further shipments across the Atlantic for conversion into refined copper.

The session of the Manchester Association of Engineers was opened on October 14 at the Engineers' Club, Albert Square, when the new president, Mr. S. H. Heywood, gave his inaugural address. Before doing so the president made two presentations. One was that of the "Constantine" medal to Mr. George E. Windeler for his paper on "Internal Combustion Engines," the other of the "Butterworth" medal to Dr. T. B. Morley for contributions to the discussions in the last session. In his address Mr. Heywood spoke of the importance of human personality in industry. There was a point reached in industry where management, he said, ceased to be a science and became an art. The loyalty of every member of an organisation to that organisation was the first essential to its industrial success, and the art of management called for those qualities which promoted sentiments of kindliness and good feeling.

The Railway Information Bureau points out that the Railways Act, 1921, decrees that the railway companies in future are entitled to earn a net revenue equal to that of the year 1913, with certain additions for new capital expended since that year, and directs the Rates Tribunal to fix standard charges at a level which, together with revenue from other sources (including that from merchandise carried at exceptional rates) will, as far as practicable, enable the companies to earn that net revenue. The keystone of the whole structure of the Act is the principle of the adjustment of charges to revenue. Formerly a railway company was entitled to keep all the profit it could make. Under the new system the Railway Rates Tribunal fix rates and charges that will yield the companies a "standard revenue" based on that of the year 1913. An annual review is to be made by the Tribunal, and, if it is found that the net revenue is in excess of the fixed revenue and is likely to continue, they will reduce rail charges so as to effect a reduction in subsequent years of 80 per cent. of such surplus. In other words, out of every £100 excess profits earned by the railways, £80 is to go to the public in reduced rates and fares. It is obvious, therefore, that traders and the public will in future have a greater interest in the prosperity of the railways, as the more traffic sent by rail the greater the prospect of reduced charges. It has been stated that the object of the revision of railway charges was to ensure the companies a sufficient revenue to enable them to pay a dividend of 5 per cent. The Railways Act guarantees no such financial results, and, while it is a fact that in a year of commercial prosperity dividends equal to those of 1913 may be possible, actual profits of the companies still depend upon the volume of traffic which they carry.

Contracts Open.

Bradford, November 12.—(1) Bolts, nuts, screws, washers, etc.; (2) files, twist drills and hack-saw blades; (5) iron, malleable iron, and steel castings: (6) phosphor-bronze, gunmetal and brass castings; (7) insulated bolts, etc.; (8) iron and steel bars, angles, channels and sheets, for 12 months from January 1, 1928, for the Tramways Committee. Mr. R. H. Wilkinson, general manager, 7, Hall Ings, Bradford.

Constantinople, November 6.—120 tons of cast-iron pipes, for the Anatolian Railway Administration. The Department of Overseas Trade, 35, Old Queen Street, S.W.1. (Ref. A.X. 5,332.)

Delhi, November 21.—Machine tools and equipment, for the Chief Controller of Stores, Indian Stores Department, Engineering Branch, Delhi. The Department of Overseas Trade, 35, Old Queen Street, S.W.1. (Ref. A.X. 5,325.)

Hull, November 7.—Three sets of pumping plant, four Lancashire boilers, economiser and water softener, for the Water and Gas Committee. Mr. W. D. Bingham, water engineer, Guildhall, Hull. (Fee £5, returnable.)

Ramleh, November 26.—A 128-kw. Diesel engine-driven electric installation, for the Ministry of the Interior. The Department of Overseas Trade, 35, Old Queen Street, S.W.1. (Ref. B.X. 3,885.)

Personal.

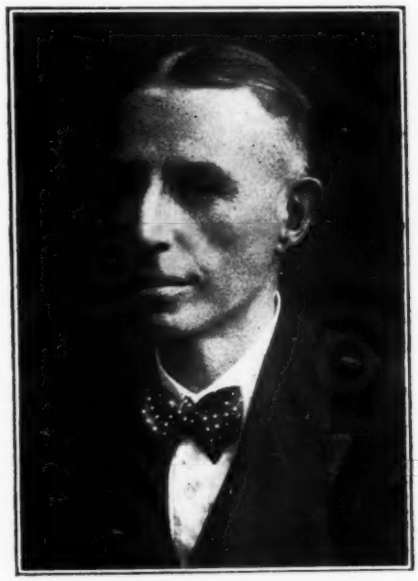
Mr. MacGrath has resigned his position as European representative of the Georgian Manganese Company, Limited, and Mr. L. W. Cross has been appointed his successor.

Mr. William O'Connor, of Penygarn, Pontyclun, who has been a member of the Institute for over 30 years, is the president-elect of the South Wales Institute of Engineers for the coming year.

Sir Basil Zaharoff, who has returned to Paris, has been the recipient of a presentation from the chairman and directors of Vickers, Limited, on the completion of 50 years' connection with the company.

The Consett Iron Company, Limited, have appointed Mr. Chas. S. Gill their agent for the Sheffield area. The office is at the White Building, Fitzalan Square, and the area covered comprises Yorkshire (south of York), and the counties of Derby, Nottingham and Lincoln. For many years Mr. Gill has been blast furnace manager to the company.

Our photograph is of Mr. J. W. Beauchamp, director and secretary of the British Electrical Development Association, whose appointment as general manager of the South Wales Power Company, Limited, and of the South Wales Electrical Power Distribution Company, Limited, is now announced. Mr. Beauchamp has long been associated with electrical power supply, mostly in industrial districts. After a course of training in London, he spent a short



Mr. J. W. Beauchamp.

time in the Midlands, and in 1900 was appointed on the electrical supply department of the Sheffield Corporation. Four years later he became deputy engineer in this department during the period when the Corporation first took up industrial power supply on a large scale. Mr. Beauchamp left Sheffield in 1909 to become chief electrical engineer to the borough of Tunbridge Wells. He was also appointed engineer and manager to the West Ham electricity department. After the War the electrical industry formed an association for development, which now covers the whole country and which Mr. Beauchamp has directed. He is a member of the Council of the Institution of Electrical Engineers, and is well known for his work on various committees interested in rural electrification and various other problems connected with the industry.

Wills.

Jones, F., of St. Malo, Oxford Road, Acocks Green, Birmingham, ironfounder	£6,288
Handley, Lieut.-Col. Arthur, a director of Cammell, Laird & Company, Limited	£9,199
Warburton, J., formerly secretary and director of S. P. Austin & Son, Limited	£4,397
MacNay, T. W., 25, Duchy Road, Harrogate, chairman of MacNay's, Limited, engineers' stores dealers	£6,170
Wilkes, E., of Four Oaks, chairman of Wilkes, Limited, nut and bolt manufacturers, Grand Junction Works, Darlaston, and of Samuel Rubery & Son, Limited, iron and steel merchants, Darlaston	£13,577

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Iron and Steel Markets.

Pig-iron.

MIDDLESBROUGH.—So far as experience has extended, the current month's business in Cleveland iron has by no means achieved the satisfactory results anticipated earlier in the quarter, when a reduction in prices induced optimistic views, which have not been realised in actual practice. At the moment, unfortunately, it has to be admitted that the temporary check to foreign competition has been succeeded by still more strenuous efforts on the part of our Continental rivals to recapture the position, with the result that French and Belgian iron now on the Tees-side market is quoted at much cheaper levels than the home product. The prejudicial effects are twofold. In the first instance, orders which under other circumstances would have been placed here are going abroad, and, secondly, buyers of Cleveland iron hesitate to place business when there is a possibility of foreign competition further depressing prices. In the conditions thus outlined, it is not surprising to note a decline in market activity, consumers as a rule holding a waiting brief, with the idea that ironmasters will shortly be compelled by circumstances to consider the advisability of again revising price-lists to lower levels. At present, however, there seems little immediate prospect of such movement on the part of the Cleveland ironmasters, who have sufficient orders in hand to keep plants working for some time, and consequently prices remain unchanged as follow:—No. 1 foundry iron, 70s.; No. 3 G.M.B., 67s. 6d.; No. 4 foundry, 66s. 6d.; No. 4 forge, 66s. per ton. These upward, the present seems a favourable moment to Scottish or foreign buyers.

Another blast furnace on hematite was blown in on Tees-side last week, but, unless an early substantial improvement in demand can be assured, this addition to productive resources can only be of problematic value, as prices are steadily declining, and quotations are now down to 72s. per ton for East Coast mixed numbers, with 72s. 6d. for No. 1 quality, both nominal. On the North-West Coast a slight improvement is reported, and prices have a stiffening tendency, Bessemer mixed numbers now being quoted at 94s. per ton at furnaces.

LANCASHIRE.—In contrast with the conditions ruling in the Cleveland area, markets for foundry pig in Lancashire have developed a steadier tendency, the downward movement in prices having been checked for the time being. There is, however, a lull in autumn buying, most consumers having already completed arrangements for the remainder of the year. Current values for delivery into this area are as follow:—Staffordshire, 73s. 9d. per ton; Derbyshire, 73s. 6d. to 74s.; Cleveland, 80s. 8d.; Scottish, 89s. 6d. to 91s.; and West Coast hematite, round 86s. 6d.

THE MIDLANDS.—Consumers of foundry pig in the South Staffordshire markets are now buying on a slightly improved scale, presumably to cover winter requirements, but business generally is steady rather than brisk in this direction. Derbyshire No. 3 foundry is quoted at 66s. for most brands, one or two asking a shilling more, and Northants varies between 60s. and 61s. for No. 3 grade, with North Staffordshire round about 65s.; these figures are f.o.t. furnaces.

SCOTLAND.—The bulk of the business now passing in local markets for foundry material is for prompt delivery, with Scotch No. 3 quality unchanged on the basis of 73s. per ton. Engineering founders are very slack, while the light castings and pipe sections in the district are also short of orders.

Finished Iron.

The recent quarterly meeting at Birmingham was not very productive from the manufacturers' point of view, and no improvement can be reported in the demand for bar iron. Marked bars remain at £13 at makers' works. There are plenty of offers for Continental No. 3 iron at about £5 15s. to £5 17s. 6d. per ton delivered here, but orders for bulk quantities are lacking. The local works' figure for nut and bolt iron is somewhere about £9, but there is little business to test the market. Quotations for crown bars rule at £9 10s. per ton, the price varying up to £10 5s. for the genuine South Staffordshire brands. Lancashire crown bars are in quiet demand at the current quotation of £10 per ton, including delivery to consumers' works.

Steel.

Reports from the various centres of the steel industry disclose few changes in the general position, which remains quiet and uneventful. At Sheffield the market for semi-products is inclined to dullness, and the demand for basic billets is tailing off, although for acid billets there is a fairly steady inquiry. The output of basic open-hearth steel is being reduced as a result of the declining demand. Crucible steel production is also on a rather smaller scale, but orders for special steels are fairly good, both on home and oversea account. In the finished steel department, business has been spasmodic, and most of the British works are anxious to secure orders. A good demand, however, has been experienced in some districts from the shipbuilders, who have recently secured orders for new vessels. Business in the tinplate market is again reported quiet, with prices about the same figures as previously quoted.

Scrap.

Conditions generally in the markets for scrap metals correspond closely with those current in pig-iron markets, business being again confined within rather narrow limits. At Middlesbrough, however, there has been a distinct improvement in the demand for nearly all classes of scrap iron and steel, and merchants now take a much more cheerful view of the outlook. They report that there are now greater opportunities for business, and perhaps, after a long period of stagnation, that is not surprising. Stocks of material must have fallen very low, and, as prices have not moved upward, the present seems a favourable moment to buy. Foundries are busier, and there is an improved demand for heavy cast iron, 61s. being still the figure for ordinary quality, and 65s. per ton for machinery quality. In Scotland, on the other hand, cast-iron scrap of all classes still remains a drug on the market. first-class machinery, suitable for foundries, being now picked up in odd lots around 67s. 6d. per ton, and for heavy ordinary cast-iron scrap to the same specification 5s. per ton less. Old cast-iron railway chairs are still around 67s. 6d. per ton, and for light cast iron and firebars 55s. to 56s. per ton is quoted, including in all cases delivery at works.

Metals.

Copper.—A general recovery in values of base metals was a distinguishing feature in last week's markets, although the total turnover was on a rather disappointing scale, sellers acting with cautious reserve for forward dates. This attitude was due to American cable advices indicating a decrease during September in the stocks at refineries and also in blister copper. The contango on forward copper has not only steadily reduced lately, but entirely vanished, which would indicate a much stronger technical position.

Official closing prices of standard copper have been as follow:—

Cash: Thursday, £55 10s. to £55 11s. 3d.; Friday, £55 10s. to £55 11s. 3d.; Monday, £55 13s. 9d. to £55 15s.; Tuesday, £56 to £56 1s. 3d.; Wednesday, £56 6s. 9d. to £56 10s.

Three Months: Thursday, £55 11s. 3d. to £55 12s. 6d.; Friday, £55 10s. to £55 11s. 3d.; Monday, £55 13s. 9d. to £55 15s.; Tuesday, £55 18s. 9d. to £56; Wednesday, £56 8s. 9d. to £56 10s.

Tin.—Recent movements in standard tin suggest a strong reaction from the low-level quotations reached of late, the price on the 13th inst. having declined to £259 10s. for cash. This is the lowest price recorded so far this year, and it compares with the highest level of £319 12s. 6d. per ton, recorded on March 4 last. In October last year the price reached £321 2s. 6d. per ton, and at that time there was much talk of a coming famine in the metal. Since then, however, the position has materially changed.

Official closing prices of standard tin have been as under:—

Cash: Thursday, £264 5s. to £264 10s.; Friday, £265 10s. to £266; Monday, £267 5s. to £267 10s.; Tuesday, £265 15s. to £266; Wednesday, £266 15s. to £266 17s. 6d.

Three Months: Thursday, £260 17s. 6d. to £261 2s. 6d.; Friday, £262 5s. to £262 7s. 6d.; Monday, £263 15s. to £264; Tuesday, £261 15s. to £262; Wednesday, £262 15s. to £263.

Spelter.—The market for ordinary spelter has improved to a slight extent, on rather more favourable American advices, but demand still continues on the slow side. Imports during September were nearly 4,000 tons higher at 14,352 tons than the imports for August. In regard to sheets, those during September, at 1,683 tons, were 99 tons lower than August.

The following are the week's prices:—

Ordinary: Thursday, £27 1s. 3d.; Friday, £26 18s. 9d.; Monday, £26 17s. 6d.; Tuesday, £26 12s. 6d.; Wednesday, £26 15s.

Lead.—It is interesting to note that the comparatively low level of values for foreign pig has had an encouraging effect on consumers, both in this country and the Continent, with the result that quite a fair business has been put through for prompt or nearby delivery. There is still no official news as to any organised reduction in production, and this is necessary before values can be expected to go very much higher.

The week's prices are appended:—

Soft foreign (prompt): Thursday, £20 12s. 6d.; Friday, £20 7s. 6d.; Monday, £20 2s. 6d.; Tuesday, £20 2s. 6d.; Wednesday, £20 10s.

HAWKINS
IMPERISHABLE
IRON CEMENT
The Cement that cannot be distinguished from the Casting. Try a tin at our expense.
Sole Manufacturers—
W. T. HAWKINS & CO.,
CHAPEL HILL, HUDDERSFIELD.

It kills the Rust!
That is why "Ruskilla" is efficient. It neutralises the rust particles present at application, and prevents further action.
It gets down to sound metal and stays there, resisting acid fumes, moisture, &c.
Rid your Foundry plant and buildings of rust!
Write to-day for price and sample.
ATLAS PRESERVATIVE CO., London, S.E.8. Ltd.
ATLAS RUSKILLA
IRON & STEEL PAINT

THOMAS E. GRAY & CO., LTD.

Ramming Exponents,

119, HIGH HOLBORN, LONDON, W.C.

Established 1877.

WEEKLY PRICE CURRENT.

COPPER.

	£	s.	d.
Standard cash	56	6	9
Three months	56	8	9
Electrolytic	62	12	6
Tough	61	0	0
Best selected	61	15	0
Sheets	86	0	0
India	71	10	0
Wire bars	62	17	6
Do. November	62	12	6
Do. December	62	12	6
Ingot bars	62	12	6
H.C. Wire rods	67	10	0
Off. av. cash, Sept.	54	9	9 5/11
Do. 3 mths., Sept.	54	19	0 5/22
Do., Sttlmnt., Sept.	54	9	9 5/11
Do., Electro, Sept.	62	0	2 5/11
Do., B.S., Sept.	60	11	11½
Aver. spot price, copper, Sept.	54	9	9½
Do., Wire bars, Sept.	62	3	10½
Solid drawn tubes			12½d.
Brazed tubes			12½d.
Wire			9½d.

BRASS.

Solid drawn tubes	11½d.
Brazed tubes	13½d.
Rods, drawn	10⅝d.
Rods, extd. or rlld.	7½d.
Sheets to 10 w.g.	9⅞d.
Wire	9⅝d.
Rolled metal	9¾d.
Yellow metal rods	7¼d.
Do. 4 × 4 Squares	8d.
Do. 4 × 3 Sheets	8½d.

TIN.

	£	s.	d.
Standard cash	266	15	0
Three months	262	15	0
English	266	0	0
Bars	267	10	0
Straits	273	0	0
Australian	271	0	0
Eastern	267	12	6
Banca	277	0	0
Off. av. cash, Sept.	280	10	10 5/11
Do., 3 mths., Sept.	276	6	2 5/22
Do., Sttlmt., Sept.	280	10	5 5/11
Aver. spot, Sept.	280	10	10¼

SPELTER.

	£	s.	d.
Ordinary	26	15	0
Remelted	25	7	6
Hard	20	15	0
Electro 99.9	30	10	0
English	27	0	0
India	22	15	0
Zinc dust	35	0	0
Zinc ashes	9	0	0
Off. aver., Sept.	27	6	8 21/44
Aver., spot, Sept.	27	6	11¼

LEAD.

	£	s.	d.
Soft foreign ppt.	20	10	0
English	21	15	0
Off. average, Sept.	21	14	4 17/44
Average spot, Sept.	21	8	11

ZINC SHEETS, &c.

	£	s.	d.
Zinc sheets, English	36	0	0
Do. V.M. ex whf.	34	10	0
Rods	42	0	0
Boiler plates	34	0	0
Battery plates	33	10	0

ANTIMONY.

	£	s.	d.
Special brands, Eng.	64	10	0
Chinese	44	0	0
Crude	37	0	0

QUICKSILVER.

	£	s.	d.
Quicksilver	22	15	0

FERRO-ALLOYS AND STEEL-MAKING METALS.

	£	s.	d.
Ferro-silicon—			
25%..	8	17	6
45/50%	12	15	0
75%..	20	0	0
Ferro-vanadium—			
35/40%	14/3 lb. va.		
Ferro-molybdenum—			
70/75% c. free	5/–lb.		
Ferro-titanium—			
23/25% carbonless	11½d.		
Ferro-phosphorus, 20/25%	£17	15	0
Ferro-tungsten—			
80/85%, c. fr.	1/3 lb.		
Tungsten metal powder—			
98/99%	1/8 lb.		
Ferro-chrome—			
2/4% car.	£33	0	0
4/6% car.	£23	0	0
6/8% car.	£22	17	6
8/10% car.	£22	10	0
Ferro-chrome—			
Max. 2% car.	£35	17	6
Max. 1% car	£41	15	0
Max. 0.70% car	£53	0	0
70% carbonless	1/4 lb.		
Nickel—99%, cubes or pellets	£170	0	0
Ferro-cobalt	9/3 lb.		
Aluminium 98/99%	£105	0	0
Metallic chromium—			
96/98%	2/11 lb.		
Ferro-manganese (net)—			
76/80%, loose	£13	0	0
76/80%, packed	£14	0	0
76/80%, export	£11	10	0
Metallic manganese—			
94/96%, carbonless	1/10 lb.		

Per ton unless otherwise stated.

HIGH-SPEED TOOL STEEL.

	£	s.	d.
Finished bars, 14% tungsten	£0	2	6
Finished bars, 18% tungsten	£0	3	0

Per lb. net, d/d buyers' works.

Extras—

Rounds and squares, 3 in. and over	4d. lb.
Rounds and squares, under ½ in. to ¼ in.	3d. lb.
Do., under ¼ in. to $\frac{5}{16}$ in.	1/– lb.
Flats, ½ in. × ¼ in. to under 1 in. × ⅛ in.	3d. lb.
Do., under ½ in. × ¼ in.	1/–lb.
Bevels of approved sizes and sections	6d. lb.

Bars cut to length, 10% extra.

Scrap from high-speed tool steel—

Scrap pieces	3d.
Turnings and swarf	1d.

Per lb. net, d/d steel makers' works.

SCRAP.

	£	s.	d.		£	s.	d.
South Wales—							
Hvy. steel			3	0	0		
Bundled steel and shrngs.			2	13	0		
Mixed iron and steel	2	12	6	to	2	15	0
Heavy cast iron	2	17	6	to	3	0	0
Good machinery for foundries			3	2	6		
Cleveland—							
Heavy steel			2	17	6		
Steel turnings			2	5	0		
Cast iron borings			2	2	6		
Heavy forge			3	12	6		
Bushelled scrap			3	2	6		
Cast-iron scrap	3	1	0	to	3	5	0
Lancashire—							
Cast-iron scrap			3	5	0		
Hvy. wrought			3	2	6		
Steel turnings			2	2	6		

London—Merchants' buying prices delivered yard.

	£	s.	d.		£	s.	d.
Copper (clean)			48	0	0		
Brass (clean)			37	0	0		
Lead (less usual draft)			18	10	0		
Tea lead			16	10	0		
Zinc			16	10	0		
New aluminium cuttings			76	0	0		
Brazierv copper			45	0	0		
Gunmetal			46	0	0		
Hollow pewter			170	0	0		
Shaped black pewter			130	0	0		

PIG-IRON.

(f.o.t. unless otherwise stated.)

	£	s.	d.		£	s.	d.
N.E. Coast—							
Foundry No. 1			70/–				
Foundry No. 3			67/6				
Foundry No. 4			66/6				
Forge No. 4			66/–				
Hematite No. 1			72/6				
Hematite M/Nos.			72/–				
N.W. Coast—							
Hem. M/Nos. d/d Glas.			83/6				
,, d/d Birm.			92/6				
Midlands—							
Staffs. common*			—				
,, No. 4 forge			—				
,, No. 3 fdry.			65/–				
Shrops. basic			—				
,, Cold blast, ord.*			—				
,, ,, roll iron*			—				
* d/d Birmingham.							
Northants forge			55/–				
,, fdry. No. 3	60/–	to	61/–				
Derbyshire forge			61/–				
,, fdry. No. 3			66/–				
,, basic			—				
Scotland—							
Foundry No. 1			—				
,, No. 3			73/–				
Hem. M/Nos.			76/–				
Sheffield (d/d district)—							
Derby forge			65/–				
,, fdry. No. 3			68/–				
Lincs. forge			—				
,, fdry. No. 3			68/–				
E.C. hematite			85/–				
W.C. hematite			90/6				
Lincs. (at furnaces)—							
Forge No. 4			—				
Foundry No. 3			—				
Basic			—				
Lancashire (d/d eq. Man.)—							
Derby forge			—				
,, fdry. No. 3			73/6				
Northants foundry No. 3			—				
Dalzell, No. 3	105/–	to	107/6				
Summerlee, No. 3	90/–	to	100/–				
Glengarnock, No. 3	90/–	to	100/–				
Gartsherrie, No. 3	90/–	to	100/–				
Monkland, No. 3	90/–	to	100/–				
Coltness, No. 3	90/–	to	100/–				
Shotts, No. 3	90/–	to	100/–				

FINISHED IRON AND STEEL.

Usual District deliveries for iron ; delivered consumers' station for steel.

Iron—	£	s.	d.		£	s.	d.
Bars (cr.) nom.	9	15	0	to	10	15	0
Angles					—		
Tees to 3 united ins.					—		
Nut and bolt iron			9	0	0		
Hoops			14	10	0		
Marked bars (Staffs.) f.o.t.			13	0	0		
Gas strip			12	10	0		
Bolts and nuts, ¾ in. × 4 in.			15	5	0		
Steel—							
Ship plates			8	2	6		
Boiler plts.			10	10	0		
Chequer plts.			10	5	0		
Angles			7	12	6		
Tees			8	12	6		
Joists			7	12	6		
Rounds and squares, 3 in. to 5½ in.			7	15	0		
Rounds under 3 in. to ⅜ in. (Untested)			8	0	0		
			and upwards				
Flats, over 5 in. wide and up			9	2	6		
Flats, 5 in. to 1½ in.			8	2	6		
Rails, heavy			8	2	6		
Fishplates			12	10	0		
Hoops (Staffs.)			10	10	0		
Black sheets, 24g.			10	12	6		
Galv. cor. shts., 24g.			13	17	6		
Galv. fencing wire 8g. plain			12	10	0		
Billets, soft	£5	15	0	to	7	0	0
Billets, hard			8	2	6		
Sheet bars	£5	12	6	to	5	15	0
Tin bars	£5	12	6	to	5	15	0

PHOSPHOR BRONZE.

	Per lb. basis.
Strip	1 2½
Sheet to 10 w.g.	1 2⅝
Wire	1 3½
Rods	1 2¾
Tubes	1 8
Castings	1 2

Delivery 3 cwt. free.
10% phos. cop. £40 above B.S.
15% phos. cop. £50 above B.S.
Phosphor tin (5%) £30 above price of English ingots.
C. Clifford & Son, Limited.

NICKEL SILVER, &c.

	per lb.
Ingots for raising	9d. to 1/3
Rolled—	
To 9 in. wide	1/3 to 1/9
To 12 in. wide	1/3½ to 1/9½
To 15 in. wide	1/3½ to 1/9½
To 18 in. wide	1/4 to 1/10
To 21 in. wide	1/4½ to 1/10½
To 25 in. wide	1/5 to 1/11
Ingots for spoons and forks	9d. to 1/5½
Ingots rolled to spoon size	1/–to 1/8½
Wire round—	
3/0 to 10 G.	1/6½ to 2/1½

with extras according to gauge.

AMERICAN IRON AND STEEL.

At Pittsburgh unless otherwise stated.

	Dols.
No. 2X foundry, Phila.	20.26
No. 2 foundry, Valley	17.50
No. 2 foundry, Birm.	17.25
Basic	20.00
Bessemer	19.76
Malleable	19.26
Grey forge	18.76
Ferro-mang. 80% d/d	90.00
Bess rails, h'y, at mill	43.00
O.-h. rails, h'y at mill	43.00
Bess billets	33.00
O.-h. billets	33.00
O.-h. sheet bars	34.00
Wire rods	43.00
	Cents.
Iron bars, Phila.	2.07
Steel bars	1.75
Tank plates	1.75
Beams, etc.	1.75
Skelp, grooved steel	1.75
Skelp, sheared steel	1.75
Steel hoops	2.30
Sheets, black, No. 24	2.90
Sheets, galv., No. 24	3.75
Sheets, blue an'l'd., 9 and 10	2.15
Wire nails	2.55
Plain wire	2.40
Barbed wire, galv.	3.25
Tinplate, 100 lb. box	85.50

COKE (at ovens).

Welsh foundry	—
,, furnace	—
Durham and North.	
,, foundry	—
,, furnace	14/–
Other Districts, foundry	—
,, ,, furnace (basis)	12/–

TINPLATES.

f.o.b. Bristol Channel ports.

I.C. Cokes	20×14	box	17/9	
,,	28×20	,,	35/6	
,,	20×10	,,	—	
,,	18¾×14	,,	—	
C.W.	20×14	,,	17/3	
,,	28×20	,,	—	
,,	20×10	,,	—	
,,	18¾×14	,,	—	
Terneplates	28×20	—	per box basis f.o.b.	

SWEDISH IRON.

Bars, hammered, £18 10 0 to 19 0 0	
Rolled Ord.	£15 0 0 to £15 10 0
Nail rods	£15 7 6 to £15 15 0
Keg. steel nom.	£33 to £35
Faggot steel nom.	£22 to £25
Blooms, according to quality	£8 to £12
Pig-iron	£5 15 0 to £6 0 0

all f.o.b. Gothenburg.

TUBES AND FITTINGS.

	Up to and incl. 6 in. Tubes.	Fittings.
Gas	67½%	45%
Water	63¾%	40%
Steam	60%	35%

W.I. 10% extra.

DAILY FLUCTUATIONS.

Standard Copper (cash).

		£	s.	d.		
Oct. 20		55	10	0	dec.	1/3
,, 21		55	10	0	No change	
,, 24		55	13	9	inc.	3/9
,, 25		56	0	0	,,	6/3
,, 26		56	6	9	,,	6/9

Electrolytic Copper.

		£	s.	d.		
Oct. 20		62	10	0	No change	
,, 21		62	10	0	,, ,,	
,, 24		62	10	0	,, ,,	
,, 25		62	12	6	inc.	2/6
,, 26		62	12	6	No change	

Standard Tin (cash).

		£	s.	d.		
Oct. 20		264	5	0	dec.	20/-
,, 21		265	10	0	inc.	25/-
,, 24		267	5	0	,,	35/-
,, 25		265	15	0	dec.	30/-
,, 26		266	15	0	inc.	20/-

Tin (English ingots).

		£	s.	d.		
Oct. 20		264	0	0	dec.	20/-
,, 21		265	0	0	inc.	20/-
,, 24		267	0	0	,,	40/-
,, 25		265	10	0	dec.	30/-
,, 26		266	0	0	inc.	10/-

Zinc Sheets (English).

		£	s.	d.		
Oct. 20		36	0	0	No change	
,, 21		36	0	0	,, ,,	
,, 24		36	0	0	,, ,,	
,, 25		36	0	0	,, ,,	
,, 26		36	0	0	,, ,,	

Spelter (ordinary).

		£	s.	d.		
Oct. 20		27	1	3	dec.	3/9
,, 21		26	18	9	,,	2/6
,, 24		26	17	6	,,	1/3
,, 25		26	12	6	,,	5/-
,, 26		26	15	0	inc.	2/6

Lead (English).

		£	s.	d.		
Oct. 20		22	0	0	No change	
,, 21		21	15	0	dec.	5/-
,, 24		21	10	0	,,	5/-
,, 25		21	10	0	No change	
,, 26		21	15	0	inc.	5/-

AVERAGE MONTHLY PRICES OF STEEL BOILER PLATES IN ENGLAND.

	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly average.
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
1895 ..	5 15 0	5 15 0	5 12 6	5 12 6	5 15 0	5 17 6	5 15 0	5 17 6	6 0 0	6 0 0	6 2 6	6 0 0	5 16 10½
1896 ..	6 0 0	6 0 0	6 2 6	6 2 6	6 2 6	6 0 0	6 0 0	6 0 0	6 0 0	6 2 6	6 10 0	6 10 0	6 2 6
1897 ..	6 10 0	6 10 0	6 10 0	6 7 6	6 2 6	6 2 6	6 5 0	6 0 0	6 0 0	6 0 0	6 7 6	6 10 0	6 5 5
1898 ..	6 10 0	6 8 9	6 8 9	6 10 0	6 15 0	6 18 9	6 17 6	6 17 6	7 2 6	6 15 0	7 0 0	7 5 0	6 15 8½
1899 ..	7 5 0	8 0 0	8 2 6	8 2 6	8 5 0	8 5 0	8 12 6	8 12 6	8 15 0	8 15 0	9 2 6	9 5 0	8 17 8½
1900 ..	9 5 0	9 5 0	9 7 6	9 10 0	9 12 6	10 5 0	10 5 0	10 5 0	10 5 0	10 0 0	9 15 0	9 15 0	9 15 10
1901 ..	9 5 0	9 5 0	8 15 0	8 10 0	8 10 0	7 10 0	7 15 0	7 15 0	7 15 0	7 15 0	7 15 0	7 15 0	8 3 11
1902 ..	7 7 6	7 0 0	7 12 6	7 12 6	7 12 6	7 10 0	7 10 0	7 10 0	7 10 0	7 10 0	7 10 0	7 10 0	7 9 7
1903 ..	7 10 0	7 10 0	7 15 0	7 5 0	7 5 0	7 5 0	7 5 0	7 0 0	7 0 0	7 0 0	7 0 0	6 17 6	7 3 11½
1904 ..	6 12 6	6 15 0	7 0 0	7 0 0	7 0 0	7 0 0	7 0 0	7 0 0	7 0 0	7 0 0	7 0 0	7 0 0	6 18 11½
1905 ..	6 17 6	6 17 6	6 17 6	6 17 6	6 17 6	6 17 6	6 17 6	6 17 6	6 10 0	7 5 0	8 0 0	8 0 0	7 1 3
1906 ..	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0	8 10 0	8 0 10
1907 ..	8 10 0	8 10 0	8 10 0	8 10 0	8 10 0	8 10 0	8 10 0	8 10 0	8 10 0	8 10 0	8 0 0	8 0 0	8 8 4
1908 ..	7 10 0	7 10 0	7 10 0	7 5 0	7 5 0	7 5 0	7 0 0	7 0 0	7 0 0	7 0 0	7 0 0	7 0 0	7 3 9
1909 ..	7 0 0	7 0 0	7 0 0	7 0 0	7 0 0	6 15 0	6 15 0	6 15 0	7 0 0	7 0 0	7 0 0	7 0 0	6 18 9
1910 ..	7 0 0	7 0 0	7 1 3	7 5 0	7 5 0	7 5 0	7 5 0	7 5 0	7 5 0	7 10 0	7 10 0	7 10 0	7 5 1
1911 ..	7 10 0	7 10 0	7 10 0	7 10 0	7 10 0	7 10 0	7 10 0	7 10 0	7 10 0	7 10 0	7 10 0	7 14 0	7 10 4
1912 ..	7 18 9	8 0 0	8 0 0	8 7 6	8 10 0	8 10 0	8 10 0	8 15 0	8 16 3	9 0 0	9 2 0	9 5 0	8 11 2½
1913 ..	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0	8 19 0	8 15 0	8 5 0	7 15 0	7 15 0	8 17 0
1914 ..	7 15 0	7 15 0	7 15 0	7 13 9	7 10 6	7 5 0	7 0 0	8 0 0	8 2 6	8 5 0	8 5 0	8 5 0	7 15 11½
1915 ..	8 14 0	9 10 0	9 17 6	10 10 0	10 10 0	11 0 0	11 0 0	11 0 0	11 0 0	11 4 0	12 0 0	13 0 0	10 15 5½
1916 ..	13 0 0	13 0 0	13 0 0	12 15 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 12 11
1917 ..	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0
1918 ..	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0
1919 ..	13 0 0	15 0 0	15 0 0	15 0 0	19 5 0	19 17 6	21 0 0	21 10 0	21 10 0	21 10 0	21 15 0	23 10 0	18 9 9
1920 ..	26 0 0	28 0 0	28 5 0	28 10 0	29 5 0	30 0 0	30 0 0	30 10 0	30 10 0	31 0 0	31 0 0	31 0 0	29 9 2
1921 ..	30 5 0	29 0 0	25 0 6	25 0 0	25 0 0	23 0 0	21 0 0	20 10 0	19 0 0	17 10 0	16 0 0	14 16 0	22 1 9
1922 ..	14 10 0	14 10 0	14 10 0	14 10 0	14 10 0	13 1 8	13 10 0	12 15 0	12 10 0	12 10 0	12 10 0	13 6 0	13 10 9
1923 ..	12 8 9	13 6 0	14 0 0	14 0 9	14 0 0	14 0 0	13 12 6	13 0 0	13 0 0	13 0 0	13 0 0	13 10 0	13 9 1½
1924 ..	13 10 0	13 10 0	13 10 0	13 10 0	13 10 0	13 10 0	13 10 0	14 0 0	14 0 0	13 11 0	13 5 0	13 5 0	13 10 11
1925 ..	13 5 0	13 5 0	13 5 0	13 1 0	12 15 0	12 15 0	12 15 0	12 15 0	12 7 6	11 14 0	11 10 0	11 10 0	12 11 5½
1926 ..	11 10 0	11 10 0	11 10 0	11 5 0	11 5 0	11 5 0	11 5 0	11 5 0	11 5 0	11 5 0	11 5 0	11 5 0	11 6 3
1927 ..	11 5 0	11 5 0	11 5 0	11 5 0	11 2 6	11 0 0	11 0 0	11 0 0	10 16 0	—	—	—	—

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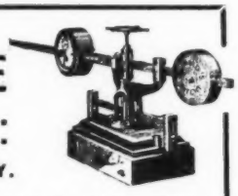

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